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Radiation Office

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	jĭ'ga	
10^{6}	mega	T	mĕg'a
10^{3}	kilo	k	kĭl'o
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn't'i
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	ăt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb.
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 12, Number 3, March 1971

Radiological Health Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Environmental Protection Agency
Atomic Energy Commission

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ENVIRONMENTAL PROTECTION AGENCY
William D. Ruckelshaus, Administrator

Reports

Summary of Environmental Monitoring at Ames Laboratory,[1] 1962-1969

J. J. Copp[2]

The Ames Laboratory Research Reactor facility (ALRR), operated for the U.S. Atomic Energy Commission by the Iowa State University of Science and Technology, reached full power in July 1965. The preoperational and present environmental monitoring program consists of gross alpha and gross beta radioactivity determinations in air, soil, vegetation, river water, ALRR outfall, river bottom sediment, precipitation, well water, and pond water samples.

The average beta radioactivity levels in air ranged from 3.86 pCi/m³ in 1963 to 0.12 pCi/m³ in 1967. The 1964 average level of beta radioactivity (1.26 pCi/m³) was about one-third of the 1962–1963 average levels.

The beta radioactivity in soil increased from 1962 to a peak of 20 pCi/g in 1964, probably due to weapons fallout, then decreased to a plateau of 13–15 pCi/g in 1965 through 1969. The alpha radioactivity increases from 1962 to 1964 and leveled to a plateau (1964–1969) of 0.7–1.0 pCi/g.

Vegetation samples show decreasing levels of beta radioactivity to 20–30 pCi/g. The alpha radioactivity in vegetation was variable with a general decrease from 1962 to 1965, leveling to 0.1–0.2 pCi/g in 1966–1968 and showing a rise to 0.91 pCi/g in 1969.

The environmental data indicate that any radiation that may have been contributed by the Ames Laboratory Research Reactor facility could not be detected.

The research group at Ames was given the responsibility of uranium metal preparation studies required for atomic bomb development in February 1942, and the uranium metal produced by this group was accepted as having the necessary quality needed for the success of the Plutonium Program (*1*). The pilot plant produced more than 2 tons of uranium ingots and part of this metal from Iowa State College was used when the world's first atomic chain reaction reached criticality on December 2, 1942 (*1*).

The Ames Laboratory Research Reactor facility (ALRR) was established to conduct research on materials in a radiation field, produce radioactive nuclides for inorganic and analytical chemistry studies, search for the relationship between structure and properties of materials, and investigate corrosion of metal containers by liquid metals in the presence of intense neutron irradiation and many other problems in chemistry, physics, metallurgy, and engineering.[3]

Today, ALRR has the finest selection of rare earth elements and compounds in the world. The rare earths are usually found in the same ores with thorium and uranium and are formed as byproducts during the irradiation of nuclear fuel[4]. They are used commercially to improve

[1] Data compiled from U.S. Atomic Energy Commission, Research and Development Reports, Survey of Environmental Radioactivity by Milo D. Voss; TID-20369 (December 31, 1963); IS-1098 (December 1964); IS-1320 (December 1965); IS-1523 (January 1967); IS-1647 (August 1967); IS-1776 (January 1968); IS-2025 (January 1969); and IS-2260 (February 1970).

[2] Mrs. Copp is with the Radiation Office, Environmental Protection Agency, Rockville, Md. 20852.

[3] U.S. Atomic Energy Commission news release of May 2, 1963.

[4] U.S. Atomic Energy Commission news release of January 14, 1966.

the properties of steel, iron, copper, aluminum, and magnesium used in a variety of metal products. In addition, they are used as catalysts, paint driers, activators for fluorescent lighting, phosphors in color television tubes and reagent chemicals.[4] Research at Ames Laboratory has included methods for separating zirconium and hafnium; methods for separating niobium and tantalum, a technique for separation of uranium-233 from thorium; and liquid metal extraction methods for removal of fission products and plutonium from power reactor fuels.[3]

The ALRR, operated for the U.S. Atomic Energy Commission by the Iowa State University of Science and Technology, is located at Ames, Iowa, approximately 30 miles north of Des Moines, Iowa. The ALRR was still under construction as of December 31, 1964, reached full power in July 1965 and had generated 87,654 megawatt-hours thermal as of June 30, 1969.

The preoperational monitoring program conducted from October 1962 to June 1965 consisted of gross alpha and gross beta radioactivity measurements on air, soil, vegetation, river water, river bottom sediment, precipitation, and well water samples. Table 1 gives the average levels of radioactivity in preoperational sampling media. From this table, one change is noticeable from the data over the 3-year period. The decreases in radioactivity reported in air and precipitation probably reflect the decreasing inventory of world-wide fallout. Since isotopic analysis was not performed on the sampled media, it is impossible to relate the sources for the increases in soil, bottom sediment, and well water samples.

The basic concept of radiological hazard control at Ames Laboratory encourages total containment of radioactive materials, and through rigid operational controls, minimizes effluent releases and external radiation levels.

Basic standards

The radiation protection standards observed at ALRR for exposure to radiation and radioactive materials both for the occupationally exposed population and for offsite exposure to the general population are those contained in Appendix 0524 of the AEC Manual.[5]

The standards specify that radiation or radioactive materials outside a controlled area which have resulted from operations within that controlled area shall be such that it is improbable that any individual will receive a dose of radiation greater than 0.5 rem in any year, and that the average exposure of a suitable population sample will not exceed one-third of this dose. To meet this standard, the average concentration of radioisotopes in air or water beyond a controlled area should not exceed one-tenth of the maximum permitted for occupational exposure (168 hours per week). For the purposes of such control, the concentrations of such radionuclides in air or water may be averaged over periods of time up to 1 year.

[5] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the same standards as the AEC Manual.

Table 1. Average levels of beta and alpha radioactivity in preoperational sampling media, ALRR, October 1962–June 1965[a]

Sampling media and concentration	Oct–Dec 1962		1963		1964		Jan–June 1965	
	Beta radioactivity	Alpha radioactivity	Beta radioactivity	Alpha radioactivity	Beta radioactivity	Alpha radioactivity	Beta radioactivity	Alpha radioactivity
Air (pCi/m³)	3.40	0.05	3.86	0.11	1.26	0.014	0.44	0.010
Soil (pCi/g)	7.57	.26	9.45	.56	20.0	.94	(b)	(b)
Vegetation (pCi/g)	117	1.62	87.5	.96	73.3	1.27	(b)	(b)
River water (pCi/liter) (total solids)	18.1	1.01	55.9	2.09	18.3	.89	26.6	.92
River bottom sediment (pCi/g)	9.88	.25	10.6	.61	11.1	.47	(c)13.9	.61
Precipitation (pCi/liter)	2,020	65.9	1,360.	39.2	366.	12.7	1,380.	5.7
Well water (pCi/liter)	4.01	.31	4.78	1.04	6.83	1.42	8.48	1.38

[a] The ALRR facility reached full power in July 1965. Preoperational sampling was carried on until that date.
[b] Soil and vegetation samples were collected in August 1965 when plant was operational.
[c] River bottom sample collected April 30, 1965.

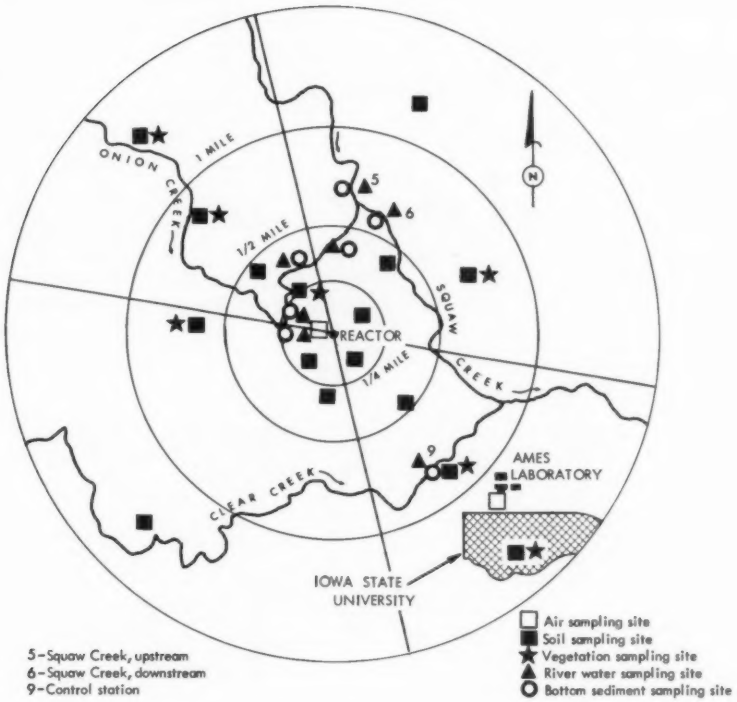

Figure 1. Environmental sampling sites within the ALRR environs

Air monitoring

Daily air samples are taken at a location on top of the Ames Laboratory Research building. Samples are collected on Whatman #41 filter paper with a Gast pump at the flow rate of 3.75 cfm. The filter samples are counted for gross alpha and gross beta radioactivity 7 days after collection to allow the decay of naturally occurring radon and thoron daughters.

Average levels of gross beta and gross alpha radioactivity in surface air at ALRR for 1962 to 1969 are given in table 2. The average beta radioactivity levels ranged from 3.86 pCi/m³ in 1963 to 0.12 pCi/m³ in 1967. The average level of beta radioactivity in 1964 was 1.26 pCi/m³, about one-third of the 1962–1963 average levels. It can therefore be assumed that the influence of the nuclear weapons tests begun in September 1961 caused the high levels in 1962 (*2*). Data for 1963 showed an anticipated spring increase resulting from the mixing of stratospheric debris into the troposphere even though the atmospheric weapons test moratorium began in December 1962 (*2*). Since the ALRR facility was still under

Table 2. Yearly average levels of radioactivity in surface air, Ames Laboratory, 1962–1969

Year	Number of samples	Concentration (pCi/m³)	
		Gross beta radioactivity	Gross alpha radioactivity
1962[a]	133	3.40	0.05
1963	263	3.86	.11
1964	310	1.26	.014
1965[b]	327	.30	.007
1966	274	.15	< .003
1967	275	.12	.004
1968	245	.20	.005
1969	187	.24	.004

[a] Air sampling program was started June 22, 1962.
[b] Reactor reached full power July 1965.

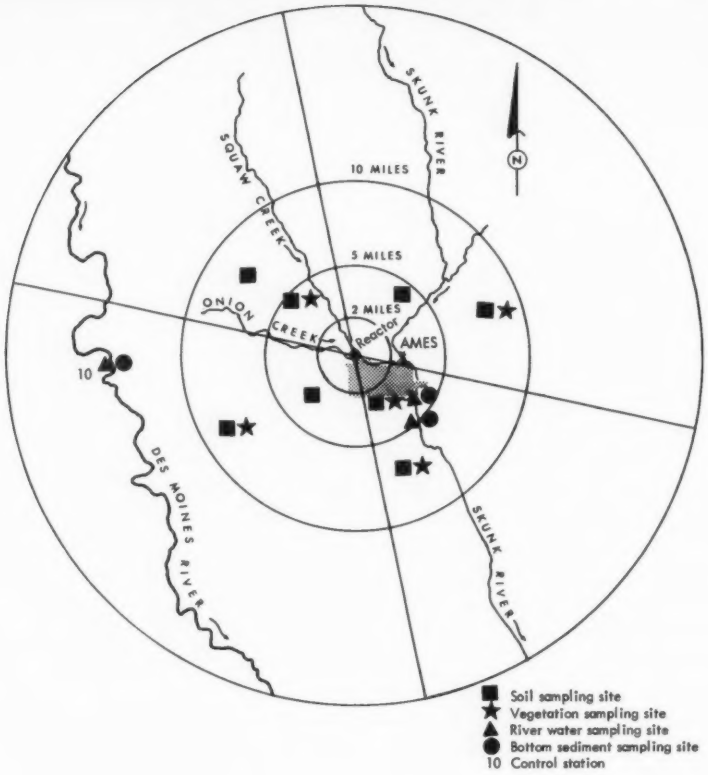

Figure 2. Offsite surveillance, ALRR

construction and did not reach full power until July 12, 1965, it is appropriate to conclude that radioactivity levels in surface air (1962–1965) resulted from atmospheric fallout and naturally occurring radioactivity.

Soil and vegetation

Soil and vegetation samples are collected once each year. Circles surrounding the ALRR site were divided into 4 sectors on the basis of wind direction frequencies. Annuli were chosen on the basis of simplicity for defining sampling areas with one sample being taken from each sector (figures 1 and 2). Reference samples are collected at Fort Dodge, Iowa.

One quart soil samples were collected from the top 2-inch layer of soil. The samples are dried thoroughly in a 100°C drying oven, mixed thoroughly, with large stones and roots being removed. A 3- to 4-gram counting sample was taken from the dried soil, placed on a 3-inch aluminum planchet and counted directly in the Sharp low-beta counting system for gross alpha and gross beta radioactivity. The accuracy of the data varies with the sample size and counting time, but is generally at least ±10 percent.

Table 3 shows the average levels of radioactivity

Table 3. Yearly average levels of radioactivity in soil samples, Ames Laboratory, 1962–1969

Year	Concentration (pCi/g dry weight)	
	Gross beta radioactivity	Gross alpha radioactivity
1962	7.57	0.26
1963	9.45	.56
1964	20.0	.94
1965	14.5	.86
1966	15.0	.68
1967	13.8	.99
1968	13.4	.81
1969	14.0	.98

in the 25 yearly samples collected from 1962 through 1969. The beta radioactivity in soil increased from 1962 to 1964, peaked in 1964 and decreased to a plateau of 13 to 15 pCi/g in 1965 through 1969. The alpha radioactivity increased from 1962 to 1964 and leveled to a plateau of 0.7–1.0 pCi/g in 1964–1969.

Thirteen yearly vegetation samples are obtained from the same location as the soil samples. Date of collection is correlated to maximum growth period, which is July and August for this area. In order to minimize surface contamination, samples are not collected after precipitation of any kind. The type of vegetation is confined to grasses, and none of the root systems are included in the samples.

Radioactivity in vegetation samples is presented in table 4 and shows decreasing levels of beta radioactivity leveling to a plateau of 20 to 30 pCi/g. The alpha radioactivity in vegetation

Table 4. Average levels of radioactivity in 13 yearly vegetation samples, 1962–1969

Year	Concentration (pCi/g dry weight)	
	Gross beta radioactivity	Gross alpha radioactivity
1962	117	1.62
1963	87.5	.96
1964	73.3	1.27
1965	32.5	.38
1966	34.0	.13
1967	20.6	.21
1968	24.9	.13
1969	30.5	.91

Table 5. Comparison of gross beta radioactivity in vegetation and soil samples collected at the same sites, Ames Laboratory environs, 1962–1969 (concentration, pCi/g dry weight)

Soil and vegetation sampling locations[a]	1962		1963		1964		1965	
	Vegetation	Soil	Vegetation	Soil	Vegetation	Soil	Vegetation	Soil
NW 1	69.4	9.0	10.5	9.9	101.	25.0	35.4	17.1
SE 3	10.8	9.4	86.0	7.8	68.0	29.5	43.0	13.1
SW 3	181.	7.0	186.	10.3	63.0	20.3	30.9	13.5
NW 3	125.	8.3	160.	8.8	67.0	19.1	29.4	12.4
NE 3	105.	9.0	126.	8.6	51.0	21.3	41.5	13.5
SE 4	42.2	8.2	84.0	9.0	87.0	21.0	43.0	15.7
NW 4	125.	5.2	58.0	9.0	65.0	21.3	29.6	13.3
SE 5	132.	6.0	62.0	8.5	55.0	19.9	31.2	15.7
NW 5	158.	6.3	87.0	8.5	80.7	18.3	26.2	15.9
SE 6	145.	7.2	62.0	8.1	124.	18.8	29.6	14.0
SW 6	132.	7.2	61.0	9.7	67.5	14.7	26.0	15.9
NE 6	132.	6.1	55.0	8.3	71.1	22.4	27.6	16.4
Control station, Ft. Dodge	167.	6.7	100.	14.0	52.1	21.2	29.0	16.6
Average	117.	7.4	87.5	9.3	73.3	21.0	32.5	14.8
Maximum	181.	9.4	186.	14.0	124.	29.5	43.0	17.1
Minimum	10.8	5.2	10.5	7.8	51.0	14.9	26.0	12.4

Soil and vegetation sampling locations[a]	1966		1967		1968		1969	
	Vegetation	Soil	Vegetation	Soil	Vegetation	Soil	Vegetation	Soil
NW 1	33.0	13.3	20.5	14.4	35.8	13.3	33.1	13.3
SE 3	33.0	15.2	26.2	14.0	24.3	12.7	32.5	14.4
SW 3	31.0	14.0	24.2	13.1	29.6	12.3	24.6	13.6
NW 3	24.0	11.0	22.0	15.5	34.5	10.5	36.9	11.7
NE 3	27.0	15.8	19.6	12.3	9.9	12.7	45.2	12.2
SE 4	33.0	35.3	21.7	14.0	26.1	13.9	46.2	15.8
NW 4	20.0	13.0	19.3	12.5	20.3	13.0	20.8	14.1
SE 5	90.0	12.7	18.9	11.5	26.8	15.5	27.8	13.6
NW 5	28.0	14.6	17.7	13.2	17.8	13.3	16.3	12.9
SE 6	23.0	11.1	17.9	11.0	22.3	11.8	28.7	12.8
SW 6	21.0	16.0	16.6	14.4	33.1	12.9	24.4	14.9
NE 6	33.0	16.1	23.8	13.4	24.6	11.6	26.9	13.3
Control station, Ft. Dodge	46.0	18.5	19.5	16.2	18.4	13.4	32.8	15.2
Average	34.0	15.9	20.6	13.5	24.9	12.8	30.5	13.7
Maximum	90.0	35.3	26.2	16.2	35.8	15.5	46.2	15.8
Minimum	20.0	11.0	16.6	11.0	9.90	10.5	16.3	11.7

[a] Sampling locations shown in figures 1 and 2.

Table 6. Comparison of gross alpha radioactivity in vegetation and soil samples collected at the same sites, Ames Laboratory environs, 1962–1969 (concentration, pCi/g dry weight)

Soil and vegetation sampling locations[a]	1962		1963		1964		1965	
	Vegetation	Soil	Vegetation	Soil	Vegetation	Soil	Vegetation	Soil
NW 1	0.45	0.25	0.63	0.33	1.31	0.53	0.61	0.78
SE 3	1.28	.23	.48	.33	1.51	.76	.64	.88
SW 3	1.89	.13	1.20	.46	1.52	1.08	.46	.99
NW 3	2.97	.16	4.10	.47	1.05	1.03	.29	.82
NE 3	2.13	.29	1.13	.63	.84	.67	.42	.64
SE 4	.74	NA	.21	.57	1.56	1.15	.35	1.15
NW 4	.44	.24	.56	.47	1.26	.88	.20	.69
SE 5	.11	.60	.15	.77	.35	.81	.16	1.15
NW 5	.16	.19	.85	.53	1.48	1.14	.26	1.20
SE 6	1.93	.18	NA	.56	3.24	.95	1.06	.56
SW 6	1.53	.21	.35	1.08	.72	.92	.07	.80
NE 6	1.46	.31	2.20	.83	.77	1.31	.25	.77
Control station, Ft. Dodge	4.00	.22	.62	.36	.86	.97	.20	.93
Average	1.62	0.23	0.96	0.56	1.17	0.94	0.38	0.87
Maximum	4.00	0.60	4.10	1.08	3.24	1.31	1.06	1.20
Minimum	0.11	0.13	0.15	0.33	0.35	0.53	0.07	0.56

Soil and vegetation sampling locations[a]	1966		1967		1968		1969	
	Vegetation	Soil	Vegetation	Soil	Vegetation	Soil	Vegetation	Soil
NW 1	ND	0.39	ND	0.83	0.22	0.06	1.63	0.91
SE 3	ND	.55	ND	.81	ND	1.01	.88	1.00
SW 3	ND	1.08	.29	.38	.24	.14	.90	1.09
NW 3	ND	.23	ND	.41	ND	.42	.67	.56
NE 3	ND	.72	ND	.71	.86	1.02	.45	1.00
SE 4	.27	1.16	.71	1.22	ND	.87	1.68	1.23
NW 4	ND	.54	.26	1.01	ND	.82	.64	1.61
SE 5	ND	.88	.48	1.16	ND	.66	.89	.92
NW 5	.77	.75	.23	1.08	ND	1.19	.67	.91
SE 6	.30	.72	ND	.76	ND	.65	1.12	.65
SW 6	.41	1.02	.21	1.27	ND	.68	.68	1.16
NE 6	ND	.78	ND	.83	ND	.93	.68	.86
Control station, Ft. Dodge	ND	1.20	.61	1.51	.34	.79	.90	1.35
Average	[b]0.44	0.77	[b]0.40	0.92	[b]0.42	0.71	0.91	1.02
Maximum	0.77	1.20	0.71	1.27	0.86	1.19	1.68	1.61
Minimum	ND	0.23	ND	0.38	ND	0.06	0.45	0.65

[a] Sampling locations shown in figures 1 and 2.
[b] Average excludes nondetectable samples.
ND, nondetectable. Detectable level varies with sample size and counting time.
NA, no analysis.

samples was variable. There is a general decrease from 1962 to 1965 to 0.1–0.2 pCi/g in 1966–1968, with a rise in 1969.

Table 5 presents the data for gross beta radioactivity of soil samples (same sampling sites as vegetation) and vegetation samples for 1962 through 1969, and table 6 shows similar data for gross alpha radioactivity.

River water samples

River water samples are collected weekly and analyzed for gross alpha and gross beta radioactivity. One-liter samples are filtered and counted separately as suspended and dissolved solids. Generally, no attempt is made to report the specific radionuclides present.

Table 7. Averages of beta radioactivity at Ames Laboratory river water sampling sites, 1963–1969 (Concentration, pCi/liter)

Site number and sampling location[a]	1963		1964		1965	
	Dissolved	Suspended	Dissolved	Suspended	Dissolved	Suspended
1–Drainage ditch, upstream	19.0	9.28	27.0	8.46	13.4	16.6
2–Drainage ditch, downstream	23.8	7.94	10.1	1.79	6.50	.76
3–Onion Creek, upstream	26.9	19.8	16.1	1.82	18.0	1.88
4–Onion Creek, downstream	18.2	8.53	10.4	1.03	6.51	.80
5–Squaw Creek, upstream	21.3	19.1	17.3	3.01	15.9	1.67
6–Squaw Creek, downstream	98.3	17.6	14.4	2.46	17.9	1.01
7–Skunk River, upstream	26.0	18.0	20.3	4.78	27.3	1.28
8–Skunk River, downstream	44.1	21.8	[c]			
9–Clear Creek	52.6	34.4	15.3	2.13	19.0	1.00
10–Des Moines River	22.1	19.0	13.7	4.58	13.1	2.62
11–Skunk River sewage outfall	23.0	25.3	18.4	2.71	12.8	.93

Site number and sampling location[a]	1966		1967		1968		1969	
	Dissolved	Suspended	Dissolved	Suspended	Dissolved	Suspended	Dissolved	Suspended
1–Drainage ditch, upstream	9.43	3.07	3.69	0.39	6.50	3.40	5.13	0.77
2–Drainage ditch, downstream	11.3	.97	9.94	1.28	[b]10.0	[b]1.16	10.9	1.32
3–Onion Creek, upstream	9.34	16.9	10.5	1.37	7.07	2.07	5.35	4.22
4–Onion Creek, downstream	4.96	.92	6.62	.57	5.61	.50	4.08	1.74
5–Squaw Creek, upstream	10.9	2.24	13.1	1.08	7.34	2.20	6.78	4.18
6–Squaw Creek, downstream	13.0	3.57	7.06	1.09	7.95	1.94	6.78	4.42
7–Skunk River, upstream	11.4	1.69	9.80	.96	8.06	2.24	6.91	4.54
9–Clear Creek	11.9	20.7	8.12	.74	8.07	2.44	5.36	2.13
10–Des Moines River	9.44	4.66	9.29	2.25	8.09	3.21	7.60	4.48
11–Skunk River sewage outfall	15.6	.74	15.8	.96	14.5	1.07	12.2	1.15

[a] Sampling sites shown in figures 1 and 2.
[b] On April 11 and 12, 1968, sodium-24 used for tracer work in the secondary cooling system was detected in the outfall water. The levels were 450 pCi/liter and 2.3 nCi/liter. The AEC standard for sodium-24 is 200 nCi/liter. On September 18–19, 1968, lutetium-177 discharged from the Reactor building was detected in the outfall water at levels of 1.17 nCi/liter and 797 pCi/liter. The AEC standard for lutetium-177 is 100 nCi/liter. As the specific isotope in the two cases was identified and the rest of the data is not otherwise specified, these four dates were not included in the averages.
[c] Site discontinued (same as Skunk River sewage outfall).

Currently, samples are obtained from each river or creek (figures 1 and 2) in the flow route of the Ames Laboratory Research Reactor drainage system. In addition, two control samples are obtained from streams outside the ALRR flow route, Clear Creek and the Des Moines River. Samples are obtained at each site until the creeks go dry in late summer or until the rivers are frozen solid in winter. If water is flowing under ice, a sample is obtained by chopping through the ice.

The suspended solids portion of the sample is prepared by igniting the filter paper directly on a planchet. The dissolved solids portion is prepared by evaporating the filtrate to near dryness and transferring the residue to a planchet. The planchets are then placed directly in the Sharp low-level system for counting.

Table 7 gives the yearly averages for gross beta radioactivity in suspended and dissolved solids in river water samples for each sampling site from 1963 to 1969. The 1962 data are not pre-

sented as they included only the last 3 months. The concentration of gross radioactivity in surface waters is extremely variable because large quantities of suspended solids lead to proportionately large values for gross radioactivity expressed only in picocuries per liter (pCi/liter). These complications have been recognized and discussed (*4*, *5*). Figure 3 provides a comparison of yearly averages of gross beta radioactivity in stations 5 and 6 (Squaw Creek, up and downstream) and the two control stations 9 and 10 (Clear Creek and the Des Moines River).

In the water sampling program at Ames Laboratory, gross radioactivity has been expressed in pCi/liter of water, however, the presentation of radioactivity in suspended and dissolved solids in picocuries per gram (pCi/g) often allows a better understanding of the movement of radiological contamination in the absence of flow data. Julian (*6*) demonstrated the usefulness of solids quality[6] in reducing the uncertainties that sometimes arise when water quality has been considered without interpretation. During periods of heavy runoff, water quality can vary enormously, and radioactive contamination is difficult to determine. In such instances, total solids content (pCi/g) of water samples can assist in the proper interpretation of the data.

[6] Water quality is customarily expressed in the form of weight per unit volume as g/liter. A water sample from a stream will contain solid material in suspension and this suspended material is considered a part of the water of the stream for defining the water quality. Gross radioactivity in pCi/liter is considered as water quality and solids quality as pCi/g.

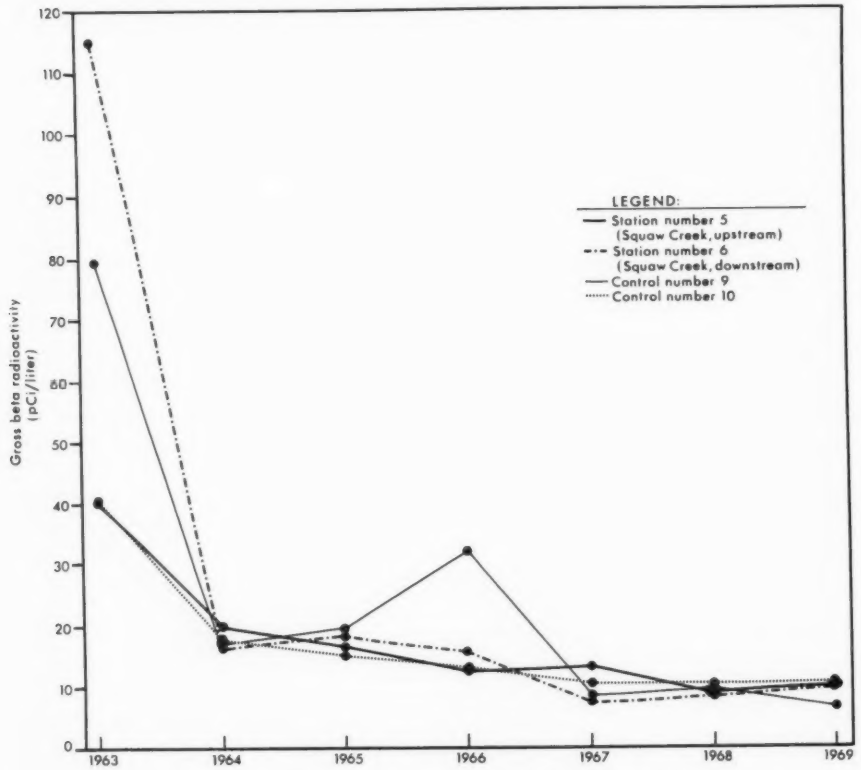

Figure 3. Comparison of yearly averages of gross beta radioactivity at four water sampling locations, ALRR, 1963–1969

River bottom sediment

Bottom sediment samples are obtained at or near the river water sampling sites on a quarterly basis and analyzed for gross alpha and gross beta radioactivity. A 1-quart sample is obtained from the top 2 or 3 inches of bottom sediment in a semiquiescent area. The sample is mixed and a counting aliquot of 3 to 4 grams is dried thoroughly in an oven and then counted directly in a Sharp low level counting system. Table 8 gives the yearly average, maximum, and minimum of gross alpha and gross beta radioactivity in river bottom sediment from 1962–1969.

Table 8. Gross alpha and gross beta radioactivity in river bottom sediment, 1962–1969

Year	Beta radioactivity[a] (pCi/g dry weight)			Alpha radioactivity[b] (pCi/g dry weight)		
	Average	Maximum	Minimum	Average	Maximum	Minimum
1962	9.88	22.7	0.60	0.25	0.94	0.09
1963	10.6	51.0	3.90	.61	8.0	.01
1964	11.1	54.0	4.50	.47	3.1	.10
1965	14.6	34.0	7.00	.89	6.7	.08
1966	13.8	31.7	5.50	.85	2.7	.06
1967	11.7	21.0	4.90	.76	2.7	.09
1968	9.84	18.4	4.10	.46	1.3	.04
1969	9.28	16.7	4.96	.49	1.5	.05

Well water

Well water samples have been collected on a monthly basis since 1962 from Ames city wells, Iowa State University (ISU) campus wells, including the ISU synchrotron well, and a privately-owned farm well located 2 miles north of the ALRR. Samples of 1 liter are filtered and counted in the same manner as the river water samples. Table 9 gives the gross alpha and gross beta radioactivity in well water samples for 1962 to 1969.

Table 9. Gross alpha and gross beta radioactivity in total solids in well water samples, Ames Laboratory 1962–1969

Year	Beta radioactivity (pCi/liter)			Alpha radioactivity (pCi/liter)		
	Average	Maximum	Minimum	Average	Maximum	Minimum
1962	4.01	6.78	2.75	0.31	0.90	0.17
1963	4.78	16.4	1.18	1.04	5.69	.10
1964	6.83	12.9	2.60	1.42	20.9	.046
1965	6.80	22.8	2.04	1.08	5.20	.12
1966	6.93	13.0	2.30	1.14	4.00	.12
1967	7.20	15.1	2.70	1.07	4.10	.18
1968	7.35	16.2	2.17	.98	1.84	.18
1969	5.81	13.1	2.20	1.09	3.46	.18

Pond water

Pond water samples have been collected monthly since 1966 from three sites: the George Todd site, 3 miles northeast of ALRR; the Izaak Walton League site, 3 miles east of the ALRR; and the Kelley site, 5 miles south of the ALRR. The sample size is 1 liter with the concentration reported in pCi/liter. The samples are filtered and prepared for counting in the same manner as the river water samples.

The averages for beta radioactivity in total solids in pCi/liter were 16.3 for 1966; 15.2 for 1967; 14.9 for 1968; and 13.7 for 1969. Alpha radioactivity levels were 0.86 pCi/liter for 1966; 1.07 for 1967; 0.83 for 1968; and 0.84 for 1969.

Precipitation

Precipitation samples are collected on an "as it happens" basis and analyzed for gross alpha and gross beta radioactivity. Samples are collected at one site, the weather observation tower near the research reactor. The samples are filtered and prepared in the same manner as the river water samples. In November 1969, it was decided that precipitation samples would no longer be filtered to help simplify and economize the program.

Table 10 gives the number of samples and the yearly averages of gross beta and gross alpha radioactivity in precipitation from 1962 to 1969. Although the data from one onsite sampling station are insufficient to assess total human radiation exposure from fallout, they can be used for determining when to modify monitoring in other phases of the environment. The average precipitation levels reported in table 10 are similar to the data presented for the Iowa area by the

Table 10. Yearly averages of gross alpha and gross beta radioactivity in precipitation, ALRR, 1962–1969

Year	Number of samples	Concentration (pCi/liter)	
		Gross beta radioactivity	Gross alpha radioactivity
1962	5	2,020	65.9
1963	62	1,360	39.2
1964	57	366	12.7
1965	57	715	3.95
1966	38	217	9.21
1967	52	75.5	3.54
1968	60	81.7	4.14
1969	82	138	9.15

Radiation Surveillance Network (changed to Radiation Alert Network in November 1967) as presented in Radiological Health Data and Reports(7).

Conclusion

The environmental sampling program is maintained to provide information regarding the effectiveness of control measures and to determine whether any radiological changes in the environment are the result of laboratory operations. Surveillance of the environmental radioactivity around Ames Laboratory from 1962 to 1969 indicates that any radioactivity contributed by the Ames Laboratory Research Reactor facility to the environment could not be detected.

Acknowledgment

Appreciation is expressed to Milo D. Voss, head, Health Physics, Ames Laboratory, USAEC, for cooperation in developing the data in this report.

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Results of Radiation Safety Surveys of X-ray Facilities within the Bureau of Prisons and Federal Health Programs Service

Lois A. Miller and *LaVert C. Seabron*[1]

This report presents the results of comprehensive surveys of x-ray facilities in 26 Bureau of Prison installations and in 11 hospitals and 20 outpatient clinics of the Public Health Service throughout the United States. Facility workloads, types of equipment, operator training, and equipment deficiencies are discussed.

During 1967, representatives of the Bureau of Radiological Health (BRH) began discussing the establishment of radiation safety programs with representatives of the Bureau of Prisons and the Federal Health Programs Service. As a result of these discussions, plans were developed for surveying and evaluating x-ray facilities at various installations of both the Bureau of Prisons and Federal Health Programs Service, and a survey program was proposed to each group.

The objectives of the proposed programs were:

1. To initiate and conduct a survey of all Bureau of Prisons and Federal Health Programs Service x-ray installations within a period of 1 year. Each survey was to include a complete radiological health and safety evaluation as it applied to the safety of patients, operating personnel, and occupants of adjacent areas.
2. To recommend modifications or changes in equipment and/or operating procedures which, when implemented, would reduce patient and occupational exposures.
3. To implement and administer a continuing program of radiation source registration.
4. To develop a system whereby all or selected facilities within the Bureau of Prisons and the Federal Health Programs Service would be resurveyed every 2 years.
5. To promote the application of radiation protection principles among personnel responsible for the operation of x-ray equipment.

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The recommendations set forth in National Council on Radiation Protection and Measurements (NCRP) Report No. 33 (*1*) and National Bureau of Standards Handbook 76 (*2*) were suggested as guides for the survey and compliance purposes of the project.

By the end of 1967, the Bureau of Prisons and Federal Health Programs Service has each signed a Memorandum of Agreement with BRH accepting the proposed program and agreeing to the facility surveys. The actual surveys were initiated in 1968 and completed early in 1969.

PROCEDURE

Survey planning

The Bureau of Prisons estimated that there were 27 installations in 22 States (figure 1) with a total of 55 medical and dental x-ray machines to be surveyed. The number of installations actually surveyed was 24 and the number of x-ray machines was 60.

The Federal Health Programs Service estimated that there were 33 facilities to be surveyed with a total of 141 x-ray machines. The actual number of facilities surveyed was 31 and the number of x-ray machines was 148. Of the 31 facilities, 11 were hospitals and 20 were outpatient clinics (figure 2).

Survey method

Procedures followed by the surveyor were identical for each installation to allow for comparison of data at the conclusion of the survey

program. The data were collected on the Public Health Service's "X-ray Protection Survey Report" forms. A specially-designed "Radiation Source Registration Form" was also used.

The equipment used by the surveyor consisted of a Victoreen Condenser R-Meter including the charger-reader and ionization chambers in the ranges of 0–10 and 0–25 roentgens full scale, an ionization chamber rate meter, spinning top, fluorescent strips for beam size determinations, steel tape measure, and assorted filters and collimators.

At each, facility the x-ray equipment was registered on a Radiation Source Registration Form, and an equipment identification decal imprinted with a registration number was affixed to the control panel of each machine. Then the machine was surveyed for compliance with the NCRP guides, and the data were entered on the appropriate forms. An evaluation was then made of the physical plant itself, including an examination of the traffic patterns within the x-ray department, the shielding incorporated in the walls of the treatment room, and the proximity of the tube to adjacent occupied areas. A check was made of the darkroom facility to ensure that it was lighttight, that a thermometer was present, that a proper safelight was in use, and that the time-temperature method of development was actually being followed.

During the course of the survey, the operator of the equipment was questioned about the procedures and techniques employed and also about the training he had received since assuming his duties.

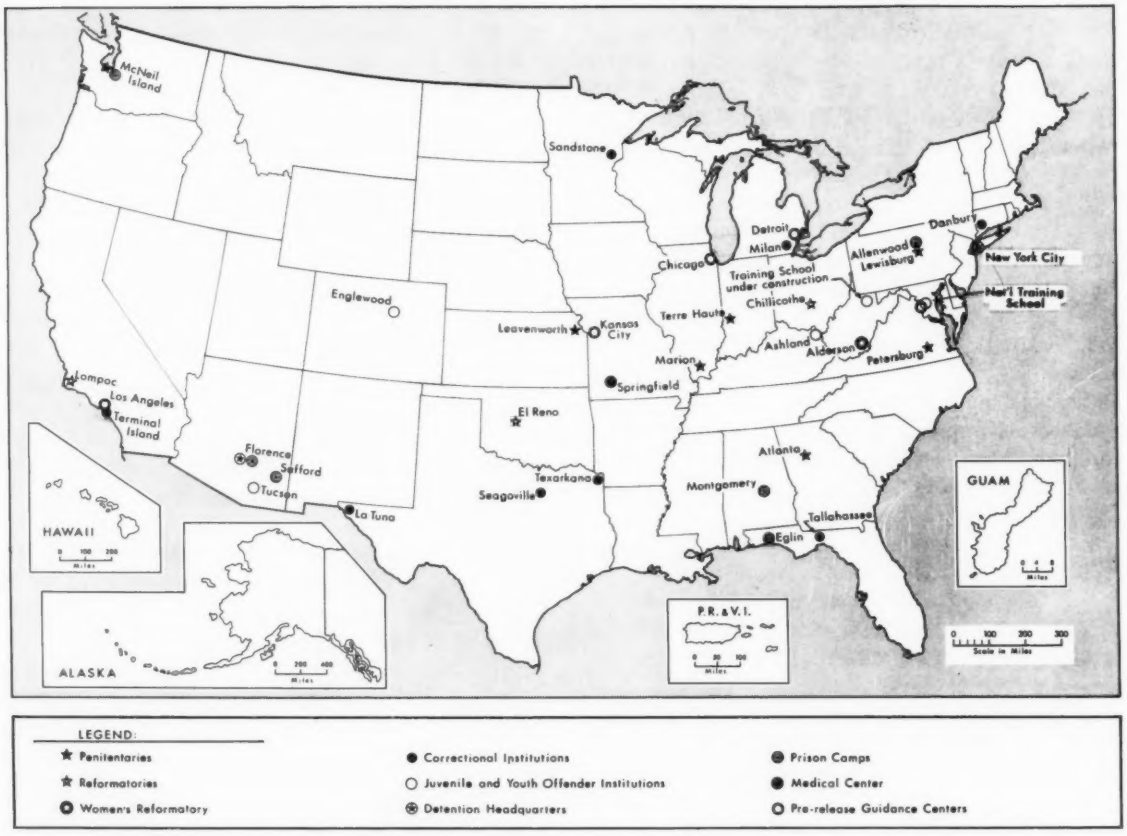

Figure 1. Federal prison system

Figure 2. Federal Health Programs Service facilities

Upon completion of the survey, the medical officer-in-charge or his designated representative was advised by the surveyor of any deficiencies noted during the survey. A comprehensive written report covering the survey was later submitted to the facility.

RESULTS

Bureau of Prisons facilities

Table 1 summarizes the personnel, equipment, and machine workloads of the Bureau of Prisons x-ray facilities surveyed.

Each facility surveyed consisted of one medical x-ray machine and one dental x-ray machine with the exception of the Medical Center for Federal Prisoners at Springfield, Mo. This facility, a 600-bed hospital for prisoners with mental and emotional disorders and chronic diseases, has an x-ray department equipped for most diagnostic and therapeutic procedures.

As of October 1, 1968, there were 20,030 prisoners in the 24 facilities surveyed. When one compares this number with the 130,208 x rays taken per year, it appears that each inmate receives an average of 6.5 x rays per year. In reality, the total number of x rays taken reflects the turnover

Table 1. Facility information for the Bureau of Prisons[a]

Facility information	Number	Average per facility
Personnel:		
Number of personnel occupationally exposed	155	6.4
Number of personnel monitored	193	8.0
Number of x-ray machine operators	114	4.7
Number of operators per machine	1.9	
Equipment:		
Total number of x-ray machines	60	2.5
Number of dental x-ray machines	25	1.0
Number of medical x-ray machines	35	1.5
Fixed radiographic	4	
Radiographic-fluoroscopic	21	
Mobile	8	
Photofluoroscopic	1	
Therapy	1	
Workload:		
Number of patients radiographed per year		
Medical	45,240	1,885
Dental	30,160	1,256
Number of exposures (films) per year		
Medical	78,125	3,255
Dental	52,083	2,169
Number of patients fluoroscoped per year	2,496	104
Number of therapy treatments per year	50	[b]
Radiographic workload mA-min per year		
Medical	30,992	1,291
Dental	4,680	195

[a] Based on 24 facilities. Does not include Morgantown, W.Va.
[b] Only 1 therapy facility in operation.

rate among inmates, annual physicals given to Justice Department employees, chest x rays to new inmates, and preemployment chest x rays for all personnel. Most of the fluoroscopic work was contracted out to local radiologists; hence, the fluoroscopic workload was low. As can be seen in table 1, the facility workloads (medical and dental) were relatively low. Although not shown in the table, the shielding (structural and added) of all facilities surveyed was found to be adequate for the workloads involved.

Table 2 presents the deficiencies noted on the diagnostic radiographic units surveyed. On 35.3 percent of the medical x-ray machines and 4.0 percent of the dental x-ray machines surveyed, the total filtration in the useful beam was found to be less than that required on the basis of the maximum tube potential. In each instance where this deficiency was noted, sufficient additional aluminum filtration was added to bring the total up to the value required by the maximum tube potential.

Table 2. Deficiencies noted for Bureau of Prisons diagnostic radiographic machines (medical and dental)

Deficiency	Number	Percent of machines surveyed that were deficient[a]
Total filtration required correction to meet appropriate standards		
Medical	12	35.3
Dental	1	4.0
Improper cone used, proper cone available		
Medical	4	11.8
Improper cone used, proper cone not available, variable collimator recommended		
Medical	7	20.6
Variable collimator present, operator not familiar with its use		
Medical	3	8.8
Beam diameter at cone tip exceeded 3 inches		
Dental	1	4.0
Timer inaccurate and/or exposure nonreproducible: Medical	1	2.9
Dental	17	68.0
Unsatisfactory operator protection		
Medical	10	29.4

[a] Based on 34 medical and 25 dental machines.

Inadequate collimation of the useful beam (in that the dimensions of the primary beam exceeded the dimensions of the film size used) was found on 32.4 percent of the medical x-ray machines surveyed. This was particularly true of those machines used almost exclusively for chest radiography.

Operator, personnel, and patient protection was found to be adequate at most fixed machine installations. In general, a lead-lined shield or booth was provided for the operator, and there was sufficient shielding to protect persons outside the x-ray room from scattered radiation. However, on 75 percent of the mobile x-ray machines the exposure switch cord length was such that it was not possible for the operator to stand at least 6 feet from the patient, the x-ray tube, and the useful beam. In each instance where the operator protection was found to be inadequate, recommendations were made which would correct the condition.

Table 3 lists the deficiencies noted on the fluoroscopes surveyed. The major deficiencies observed were the absence of Bucky-slot covers, failure of the diaphragm system to restrict the x-ray beam to the area of the viewing screen, and the absence of a protective drape between the patient and fluoroscopist to intercept scattered radiation. The high incidence of these three deficiencies may be used as an index of the age of the x-ray machines surveyed inasmuch as they are likely to be found on fluoroscopes manufactured prior to 1960. On machines manufactured after that date these appurtenances appear as standard equipment. The fact that the four fluoroscopes with no deficiencies had all been purchased within the past 4 years tends to support this thesis.

Table 3. Deficiencies noted on Bureau of Prisons fluoroscopic units

Deficiency	Number	Percent of machines surveyed[a]
Lead protective gloves and aprons not available or not used	1	5.9
Protective cover for Bucky-slot absent	7	41.2
Diaphragm system permits x-ray beam to exceed area of viewing screen	10	58.8
Manually reset cumulative timer to indicate elapsed time absent	1	5.9
Protective drape to intercept scattered radiation absent between patient and fluoroscopist	13	76.5

[a] Based on 17 facilities with fluoroscopes in operating condition.

In none of the fluoroscopes surveyed was the total filtration in the primary beam less than 2.5 mm aluminum equivalent. The exposure rate at the panel top of all fluoroscopes surveyed when operated at 80 kVp, was found to be equal to or

less than 3.2 R/mA-min. There was no instance of excessive transmission of the x-ray beam through the viewing screen. As in the case of those radiographic machines where deficiencies were noted, recommendations were made for correction of the deficiencies.

Dental x-ray machine timer accuracy and/or reproducibility of exposures proved to be deficient in a surprisingly large number of cases. To be considered accurate, the timer should deliver exactly the exposure time for which it has been set. Reproducibility is the ability to give the same exposure time in successive tests in which the timer setting remains the same. Of the two, reproducibility is the most important from the standpoint of reducing unnecessary radiation exposure. By adjusting the timer setting, the operator can compensate for a timer that is known or suspected to be inaccurate, provided the exposure time is consistent in succeeding exposures. A timer that has poor reproducibility of exposures makes it almost impossible for the operator to compensate for this defect because of the variation in exposure time. Thus, the patient may receive unnecessary exposure from retakes necessitated by the unacceptable films produced as a result of the faulty timer.

The spinning top test which provides a visual comparison between x-ray pulse production and timer setting was used to measure timer system accuracy and exposure reproducibility. The test was performed on all dental x-ray machine timers. The timer settings checked in the test were those reported by the dentist or his assistant as being used for upper molars. Four successive tests were conducted at each setting using accuracy specifications described in the Federal specifications (*3*). "The timer shall be accurate to plus or minus 5 percent at any setting over 1 second, and plus or minus 10 percent at any setting under 1 second." Most dental x-ray exposure times are under 1 second; therefore, to be considered as having acceptable accuracy, the number of x-ray pulses observed on the developed film had to be within plus or minus 10 percent of the number of pulses equivalent to the timer setting.

Table 4 depicts the accuracy and reproducibility of the timing system on the dental x-ray machines surveyed. From these results, it can be seen that 15 of the 25 timing systems tested (60 percent) failed to meet the standards set for both accuracy and reproducibility. Two timers (8 percent) were inaccurate but had good reproducibility, and only 8 timers (32 percent) met the standard for both accuracy and reproducibility.

Table 4. Accuracy and exposure reproducibility of Bureau of Prisons dental x-ray machine, timing systems at selected settings

Findings		Manufacturers			
Accuracy	Exposure reproducibility	Weber	Ritter	XRMC	Total
Acceptable	Acceptable	2	6	0	8
Acceptable	Unacceptable	0	0	0	0
Unacceptable	Acceptable	1	0	1	2
Unacceptable	Unacceptable	12	3	0	15
Total		15	9	1	25

Although the number of machines and manufacturers covered during the survey may not constitute a representative sample, the data did indicate that timer accuracy and reproducibility were problems in machines produced by certain manufacturers. The timing systems on the two Weber x-ray machines that were acceptable for both accuracy and exposure reproducibility were replacement systems for defective original equipment.

The most notable deficiency observed during the surveys was that of operator training. At each of the facilities surveyed, the principal operator of the medical and dental x-ray equipment was an inmate technician who, as might be expected, had had no prior training in radiological technology. Although the medical-technical assistants assigned to each facility had had some formal training and experience in radiological technology, the duties assigned to these individuals made it almost impossible for them to devote much of their time to the training of inmate technicians. Because of the manner in which the on-the-job training of technicians was conducted, poor techniques tended to be passed from technician to technician. This fact was especially evident at those facilities with x-ray machines equipped with variable collimators. In general, the operators of these x-ray machines did not know how to use the collimator properly; therefore, its value as a mechanism for reducing unnecessary radiation exposure was correspondingly reduced.

Table 5. Facility information for the Federal Health Programs Service

Facility information	Information for facility not determined	Number of facilities reporting	Number	Average per facility
Personnel:				
Number of personnel occupationally exposed	4	27	239	8.9
Number of personnel monitored	7	24	282	11.7
Number of x-ray machine operators	3	28	210	7.5
Number of operators per machine			1.4	
Equipment:				
Total number of x-ray machines		31	148	4.8
Number of dental x-ray machines		31	44	1.4
Number of medical x-ray machines		31	104	3.4
Fixed radiographic		31	35	1.1
Radiographic-fluoroscopic		31	41	1.3
Mobile		31	22	.7
Photofluorographic		31	2	.06
Therapy		31	4	.1
Workload:				
Number of patients radiographed per year				
Medical		31	369,184	11,909
Dental		31	37,664	1,215
Number of exposures (film) per year				
Medical		31	907,648	29,279
Dental		31	140,816	4,542
Number of patients fluoroscoped per year	5	26	19,968	768
Number of therapy treatments per year		31	6,812	
Radiographic workload (mA-min/a)				
Medical	1	30	127,903	4,263
Dental	4	27	27,477	1,018

Federal Health Programs Service facilities

Table 5 summarizes the personnel, equipment, and machine workloads of the Federal Health Programs Service x-ray facilities surveyed. In general, each facility surveyed consisted of one or two dental x-ray machines and three or four medical x-ray machines. Of the 1,048,464 film exposures per year, 731,172 or 69.7 percent were reported by hospitals. The estimated number of patients per year reported by the hospitals was 257,608.

Table 6 presents the deficiencies noted on the diagnostic radiographic units surveyed (eight units were in storage or not used). For 2.2 percent of the medical machines surveyed, the total filtration in the useful beam was found to be less than that required on the basis of the maximum tube potential. Total filtration was adequate on all dental units. In each instance where this deficiency was noted, sufficient additional aluminum filtration was added to bring the total up to the value required by the maximum tube potential.

Inadequate collimation of the useful beam, in that the dimensions of the primary beam exceeded the dimensions of the film, was found on 3.3 percent of the medical x-ray machines surveyed.

Although 63 percent of the medical x-ray machines surveyed were equipped with a variable collimator which gave a visible indication of beam size, many of the operators of the machines did not know how to use the collimator correctly.

Table 6. Deficiencies noted on Federal Health Programs Service diagnostic radiographic machines

Deficiency	Number	Percent of machines surveyed[a]
Total filtration required correction to meet appropriate standards (medical)	2	2.2
Excessive beam size (medical)	3	3.3
Improper cone used, proper cone not available, variable collimator recommended (medical)	3	3.3
Variable collimator not functioning properly (medical)	4	4.3
No collimator or cones available (medical)	2	2.2
Beam diameter at cone tip exceeded 3 inches (dental)	0	0
Timer inaccurate and/or exposure nonreproducible: Medical	11	11.9
Dental	14	31.8
Unsatisfactory operator protection (medical)	5	5.4
Exposure control switch cord inadequate (mobile)	16	72.7

[a] Based on 92 medical and 44 dental machines.

X-ray machine timer accuracy and/or exposure reproducibility proved deficient in 11.9 percent of the medical x-ray units and 31.8 percent of the dental x-ray units.

Operator, personnel, and patient protection was found to be adequate at most fixed machine installations. In general, a lead-lined shield or booth was provided for the operator, and there was sufficient shielding to protect persons outside of the x-ray room from scattered radiation. However,

on 72.7 percent of the mobile x-ray machines, the length of the exposure switch cord made it impossible for the operator to stand at least 6 feet from the patient, the x-ray tube, and the useful beam. In each instance where operator protection was found to be inadequate, recommendations were made to correct the condition.

Table 7 lists the deficiencies noted on the fluoroscopes surveyed. Four of the 41 fluoroscopes were not used. The major deficiencies observed were the absence of Bucky-slot covers, failure of the diaphragm system to restrict the x-ray beam to the area of the viewing screen, and the absence of a protective drape between the patient and fluoroscopist to intercept scattered radiation.

Table 7. Deficiencies noted on Federal Health Programs Service fluoroscopic units

Deficiency	Number	Percent of machines surveyed[a]
Leaded protective gloves not available or not used	1	2.7
Protective cover for Bucky-slot absent	7	18.9
Diaphragm system permits x-ray beam to exceed area of viewing screen	4	10.8
Manually reset cumulative timer to indicate elasped time absent	2	5.4
Protective drape to intercept scattered radiation absent between patient and fluoroscopist	10	27.0
Excessive transmission of x-ray beam through viewing screen	1	2.7
Total filtration in useful beam less than 2.5 mm aluminum equivalent	1	2.7
Exposure rate at panel top greater than 3.2 R/mA-min when operated at 80 kVp	0	0

[a] Based on 37 fluoroscopes.

The high incidence of these three deficiencies indicates the age of the x-ray machines surveyed inasmuch as they are likely to be found on fluoroscopes manufactured prior to 1960.

In only one of the machines surveyed was the total filtration in the primary beam less than 2.5 mm aluminum equivalent. The exposure rate at the panel top of all fluoroscopes surveyed was found to be equal to or less than 3.2 R/mA-min when operated at 80 kVp. There was one instance of excessive transmission of the x-ray beam through the viewing screen. As in the case of those radiographic machines on which deficiencies were noted, recommendations for correction of the deficiencies were made.

Only four therapy machines were surveyed, and no deficiencies were found.

One of the most important deficiencies observed during the surveys was that of operator training. This problem occurred primarily in smaller installations where a medical technician was required to double as an x-ray technician with little or no formal training. On the other hand, the large installations quite often had an overabundance of trained x-ray technicians who could have been used elsewhere.

Conclusions

An analysis of the data collected revealed that the major problem areas are inadequate training of x-ray machine operators and the modification of existing equipment so that it meets currently accepted standards.

The following actions have been taken to correct the deficiencies:

1. Radiation safety courses
   a. Bureau of Prisons: A radiation safety course for Medical Technical Assistants was presented at the Medical Center, Springfield, Mo., during March 1970.
   b. Federal Health Programs Service: A radiation safety course was presented at Staten Island, N.Y., during March 1970.
2. Modifications to equipment have been made as recommended.
3. The Weber Dental Company was notified of the deficiencies in its machines; attempts at corrective action are in progress.
4. The facility survey agreements were renegotiated; the surveys will be repeated at a regular frequency.

The mention of commercial products is not to be construed as either an actual or implied endorsement of such products by the Department of Health, Education, and Welfare.

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Color Television Survey in Pennsylvania

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During 1968–1970, 322 color television sets in Pennsylvania were surveyed for emission of x radiation. Eighty-eight percent were found to emit radiation less than or equal to 0.1 mR/h at 5 cm. Two percent emitted radiation in excess of 0.5 mR/h. It was determined from the survey that the primary cause for excess radiation from color television sets is related to high voltage adjustments. It was found that two of the sets emitting radiation in excess of 0.5 mR/h were serviced shortly before the investigation. Voltage readings as high as 39 kV were observed.

On October 18, 1968, the 90th Congress of the United States enacted Public Law 90-602 entitled the "Radiation Control for Health and Safety Act of 1968." Shortly thereafter, standards for radiation emission for color television sets were published in the Federal Register (*1*). These standards state that the radiation exposure rate in air 5 cm from any point on the external surface of a television receiver shall not exceed 0.5 mR/h.

Following the publication of a newspaper article, the Office of Radiological Health of the Pennsylvania Department of Health received 343 requests for x-ray surveys of color television sets. Requests were honored until February 23, 1970. Subsequently, persons requesting surveys received a letter giving the results of this survey, recommendations for proper viewing of color television and the suggestion that a serviceman check the set for proper electrical operation. Of the 343 requests received, 322 color television sets were surveyed.

The survey instruments used during the survey were end-window Thyac II GM counters and Victoreen 440 RF ion chambers. The readings from the GM counters were found to be in close agreement with the ion-chambers. However, the GM counters were not calibrated for the specific energy levels associated with color television.

Two hundred and eighty-two sets (87.6 percent) were found to emit radiation less than or equal to 0.1 mR/h. Thirty-three sets (10 percent) emitted radiation at levels greater than 0.1 but less than 0.5 mR/h. Seven sets (2 percent) emitted radiation in excess of 0.5 mR/h. Table 1 shows the breakdown by manufacturers of the sets involved in the survey. Of the seven sets which had readings in excess of 0.5 mR/h, five were manufactured by RCA. It is important, however, to note that RCA was the manufacturer of approximately one-third of all sets inspected.

By previous arrangements, RCA was notified of the five RCA sets emitting radiation in excess of 0.5 mR/h found in the survey. Representatives of RCA and a representative from the Office of Radiological Health, Pennsylvania Department of Health, visited the residences of the individuals possessing these sets. Only three of the individuals could be contacted by either RCA or the Office of Radiological Health to establish appointments. In all three cases, the sets were measured by both RCA and the Office of Radiological Health representative using Victoreen 440 RF ion chambers. In all instances, the measurements

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Table 1. Results of color television survey Pennsylvania, 1968–1970

Manufacturers	Number of sets			Model and year
	≤0.1 mR/h	>0.1–<0.5 mR/h	>0.5 mR/h	
Admirial	19	0	1 (1.0 mR/h)	1965
Dumont	1	1	0	
General Electric	18	1	0	
Heathkit	1	0	0	
JVC Nivico Vision	2	0	0	
Magnavox	15	0	0	
Motorola	22	1	0	
Olympic	1	1	0	
Philco	19	3	0	
RCA	99	17	5 (2.0 mR/h)	GG583W 1965
			(.7 mR/h)	Unknown 1965
			(2.5 mR/h)	GJ705W 1965
			(3.0 mR/h)	GJ705W 1968
			(1.0 mR/h)	8322–6 1968
Sears	17	0	0	
Sharp	1	0	0	
Sylvania	9	1	0	
Westinghouse	1	0	0	
Zenith	57	8	1 (1.0 mR/h)	Unknown
Total	282	33	7	
Grand total	322			

agreed with the initial reading determined by the previous survey. Measurements indicated that the line voltage to the three sets involved was 119 volts. The high voltage output to the picture tube was 29 kV, 37 kV, and 39 kV, respectively. Increasing the high voltage output tends to give a brighter picture, a temporary step and one that should not be taken. It was interesting to note that the two sets having the highest voltage had been serviced by a repairman within the preceding 2 weeks. The RCA representatives reduced the voltage to 24.5 kV and made other necessary adjustments to produce a picture satisfactory to the owners. After the final adjustments were completed, a radiation emission survey of the sets was made. In all three cases, readings of less than or equal to 0.1 mR/h were observed.

Summary

The survey of color television sets in Pennsylvania showed that only 2 percent of the sets surveyed emitted radiation higher than the standard of 0.5 mR/h at 5 cm from the set. Two out of three sets emitting excessive radiation were found to have the high voltage far in excess of that specified by the manufacturer. It appears that television servicemen need to be reminded that improper adjustment of the high voltage on a color television set can create a radiation hazard.

Other causes of excessive radiation emission, such as defective shunt regulator tubes and lack of proper radiation shielding, were not observed during the survey.

The following recommendations appear appropriate for Pennsylvania color television owners:

1. Color television sets purchased before January 15, 1970, should be viewed from a distance of at least 6 feet; television sets purchased after that date must meet more stringent standards and should not present a radiation problem (*2*), and
2. Only qualified persons should repair or service the set.

REFERENCE

(*1*) PUBLIC HEALTH SERVICE, DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE. Performance standard for television receivers. Federal Register 34:20, 273–275 (December 25, 1969).

(*2*) PUBLIC HEALTH SERVICE, DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE. What's being done about x-rays from home TV sets, BRH/P5. Bureau of Radiological Health, Rockville, Md. 20850 (January 1971).

Technical Notes

Strontium-90 and Cesium-137 Levels in the Diet of Children on a School Lunch Program

P. S. Weng and *C. N. Hsu*[1]

The school lunch program supported by the United Nations is a special project at Hsinchu, Taiwan, Republic of China, to provide the primary school children with a nutritious lunch containing flour products as the main course. The flour products are made primarily from wheat imported from the United States, Canada, and Australia. It is contrary to the diet of adults who prefer to have rice and soup for their lunch, and a comparison of the fallout nuclides in the lunches of school children and adults is thus investigated.

Since 1969, school children's lunches at a nearby primary school have been sampled daily except weekends, holidays, and vacations. The analysis of adult lunch has long been a routine survey at Tsing Hua University, and the sampling is taken at the University's cafeteria. Radiochemical methods (*1*) are used to determine the nuclides existing in the diet with reference to strontium-90, cesium-137, potassium, and calcium.

Figure 1 shows the average daily intake of strontium-90 and cesium-137 during the observation periods. The comparison of average strontium-90 and cesium-137 concentrations in school children's lunch and in an adults' lunch is shown in table 1. Though the counting error is within 15 percent, the activities in the school children's lunch still show higher values than those in the adults' lunch. This may be attributed to the imported wheat which has a higher fallout content than the locally grown rice.

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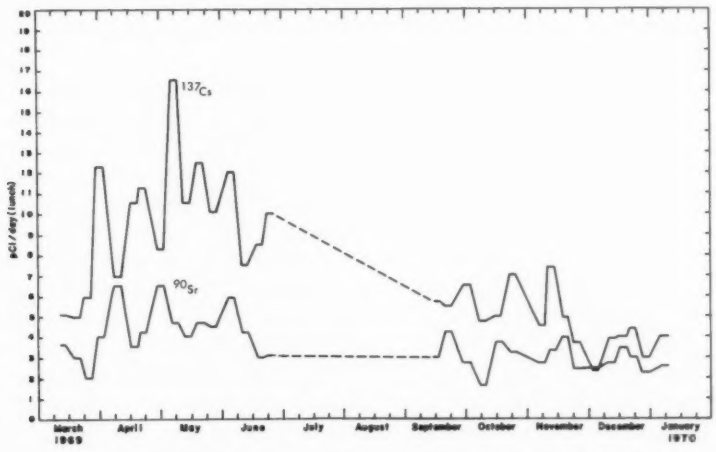

Figure 1. Daily intake of strontium-90 and cesium-137 in school children's lunch at Hsinchu, Taiwan Republic of China

Table 1. The comparison of average strontium-90 and cesium-137 concentration in school children's lunch and in adults' lunch in Hsinchu, Taiwan, Republic of China

Lunch	Potassium		Cesium-137			Calcium	
	$\left(\frac{mg}{100mg\text{-}ash}\right)$	$\left(\frac{g}{kg\text{-}fresh}\right)$	$\left(\frac{pCi}{g\text{-}ash}\right)$	$\left(\frac{pCi}{kg\text{-}fresh}\right)$	$\left(\frac{pCi}{g\ K}\right)$	$\left(\frac{mg}{100mg\text{-}ash}\right)$	$\left(\frac{g}{kg\text{-}fresh}\right)$
School children's lunch	9.96	0.96	0.70	6.75	7.03	3.42	0.33
Adult's lunch	7.72	.71	.32	2.94	4.15	2.47	.23

Lunch	Strontium-90			$\left(\frac{^{137}Cs}{^{90}Sr}\right)$	Total gross beta activity	
	$\left(\frac{pCi}{g\text{-}ash}\right)$	$\left(\frac{pCi}{kg\text{-}fresh}\right)$	$\left(\frac{pCi}{g\text{-}Ca}\right)$		$\left(\frac{pCi}{g\text{-}ash}\right)$	$\left(\frac{pCi}{kg\text{-}fresh}\right)$
School children's lunch	0.37	3.57	10.82	1.89	75.47	728.26
Adult's lunch	.23	2.11	9.31	1.38	59.87	549.86

REFERENCE

(*1*) U.S. ATOMIC ENERGY COMMISSION. Manual of standard procedures, NYO–4700. U.S. Atomic Energy Commission, Health and Safety Laboratory, New York, N. Y. (1967).

SECTION I. MILK AND FOOD

Milk Surveillance, November 1970

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Radiation Office, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabo-

Figure 1. Milk sampling networks in the Western Hemisphere

lically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2-standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Radiation Office conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during May-July 1970, with 28 laboratories participating in an experiment on milk samples containing known concentrations of strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 (*5*). Of the 20 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 13 participated in the experiment.

The accuracy results of this experiment are shown in table 1. In general, considerable improvement is needed, especially in the accuracy measurements. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category			
	Acceptable[a]	Warning level[b]	Unacceptable[c]	Total
Strontium-89: High (258 pCi/liter)	7 (44%)	1 (6%)	8 (50%)	16
Low (15 pCi/liter)	11 (69%)	3 (19%)	2 (12%)	16
Strontium-90: Intermediate (79.4 pCi/liter)	13 (57%)	4 (17%)	6 (26%)	23
Low (32.0 pCi/liter)	5 (25%)	4 (20%)	11 (55%)	20
Iodine-131: High (507 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
Low (49 pCi/liter)	16 (64%)	3 (12%)	6 (24%)	25
Cesium-137: High (259 pCi/liter)	20 (74%)	3 (11%)	4 (15%)	27
Low (53 pCi/liter)	17 (66%)	5 (19%)	4 (15%)	26
Barium-140: High (302 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
Low (33 pCi/liter)	23 (92%)	0	2 (8%)	25

[a] Measured concentration less than or equal to 2σ of the known concentration.
[b] Measured concentration greater than 2σ and less than or equal to 3σ of the known concentration.
[c] Measured concentration greater than 3σ of the known concentration.

been referenced in earlier reports appearing in *Radiological Health Data and Reports.*

A previous article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and an earlier data article for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short time periods, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data presentation (table 2) also reflects whether raw or pasteurized milk was collected. An analysis of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that, for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*7*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels are given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity

Table 2. Concentrations of radionuclides in milk for November 1970 and 12-month period December 1969 through November 1970

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium–90		Iodine–131		Cesium–137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	NA	6	0	0	0	8
Alaska:	Palmer[c]	P	7	6	0	0	17	10
Ariz:	Phoenix[c]	P	NA	1	0	0	0	0
Ark:	Little Rock[c]	P	12	13	0	0	12	17
Calif:	Sacramento[c]	P	NA	2	0	0	0	0
	San Francisco[c]	P	NA	2	0	0	0	0
	Del Norte	P	12	18	0	0	14	15
	Fresno	P	2	2	0	0	0	2
	Humboldt	P	4	5	0	0	8	5
	Los Angeles	P	1	2	0	0	0	2
	Mendocino	P	1	4	0	0	0	2
	Sacramento	P	2	2	0	0	0	2
	San Diego	P	2	2	0	0	0	1
	Santa Clara	P	2	2	0	0	0	1
	Shasta	P	4	3	0	0	6	2
	Sonoma	P	2	3	0	0	2	2
Colo:	Denver[c]	P	NA	5	0	0	0	1
	West	R	(d)		NS	(e)0	NS	4
	Northeast	R	(d)		(e)0 (8)	(e)0	(e)0 (8)	(e)0
	East	R	(d)		(e)0	(e)0	(e)0	(e)0
	Southeast	R	(d)		NS	(e)0	NS	(e)0
	South Central	R	(d)		NS	NS	NS	NS
	Southwest	R	(d)		NS	(e)0	NS	7
	Northwest	R	(d)		NS	6	NS	0
Conn:	Hartford[c]	P	NA	8	0	0	0	11
	Central	P	8	7	0	0	16	14
Del:	Wilmington[c]	P	NA	9	0	0	0	7
D.C:	Washington[c]	P	NA	7	0	0	0	6
Fla:	Tampa[c]	P	6	5	0	0	47	51
	West	R	5	9	0	0	22	17
	North	R	5	10	0	0	30	24
	Northeast	R	7	6	0	0	44	43
	Central	R	6	7	0	0	19	56
	Tampa Bay area	R	5	6	0	0	49	50
	Southeast	R	8	7	14	1	136	75
Ga:	Atlanta[c]	P	NA	10	0	0	12	16
Hawaii:	Honolulu[c]	P	0	2	0	0	0	0
Idaho:	Idaho Falls[c]	P	4	5	0	0	20	6
Ill:	Chicago[c]	P	7	7	0	0	0	10
Ind:	Indianapolis[c]	P	NA	8	0	0	0	6
	Northeast	P	12	10	0	1	15	14
	Southeast	P	11	11	0	0	10	12
	Central	P	9	9	0	0	0	10
	Southwest	P	10	12	0	0	10	12
	Northwest	P	14	11	0	0	15	14
Iowa:	Des Moines[c]	P	NA	7	0	0	0	2
	Iowa City	P	4	7	0	0	11	11
	Des Moines	P	6	8	0 (4)	0	15 (4)	8
	Spencer	P	6	6	0	0	15	7
	Fredericksburg	P	NS	NS	NS	NS	NS	NS
Kans:	Wichita[c]	P	NA	8	0	0	12	3
	Coffeyville	P	9	9	21	2	13	1
	Dodge City	P	8	7	0	0	10	2
	Falls City	R	5	7	16	3	11	4
	Hays	P	12	14	0	1	0	1
	Kansas City	P	6	8	0	0	12	4
	Topeka	P	13	10	19	2	0	3
	Wichita	P	10	12	0	0	10	1
Ky:	Louisville[c]	P	NA	8	0	0	0	4
La:	New Orleans[c]	P	14	15	0	0	20	19
Maine:	Portland[c]	P	NA	10	0	0	22	22
Md:	Baltimore[c]	P	NA	7	0	0	0	7
Mass:	Boston[c]	P	10	10	0	0	19	21
Mich:	Detroit[c]	P	NA	8	0	0	0	8
	Grand Rapids[c]	P	NA	9	0	0	0	11
	Bay City	P	NS	7	NS	(e)0	NS	10
	Charlevoix	P	NA	13	(e)0 (4)	(e)1	13 (4)	16
	Detroit	P	NA	8	(e)0	(e)0	13	8
	Grand Rapids	P	NA	9	(e)0	(e)0	13	9
	Lansing	P	NA	9	(e)0 (3)	(e)0	13 (3)	14
	Marquette	P	NA	14	(e)0 (2)	(e)0	21 (2)	23
	Monroe	P	NA	6	(e)0 (2)	(e)0	0 (2)	3
	South Haven	R	NA	8	(e)0 (5)	(e)0	8 (5)	7
Minn:	Minneapolis[c]	P	NA	9	0	0	21	10
	Bemidji	P	8	10	0	0	15	21
	Mankato	P	4	4	0	0	0	11
	Rochester	P	7	6	0	0	0	11
	Duluth	P	14	14	0	0	22	27
	Worthington	P	4	4	0	0	0	0
	Minneapolis	P	11	9	0	0	18	16
	Fergus Falls	P	5	6	0	0	17	13
	Little Falls	P	20	11	0	0	25	33

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for November 1970 and 12-month period December 1969 through November 1970—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium–90		Iodine–131		Cesium–137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
Miss:	Jackson[c]	P	NA	12	0	0	11	12
Mo:	Kansas City[c]	P	NA	8	0	0	0	2
	St. Louis[c]	P	NA	8	0	0	0	4
Mont:	Helena[c]	P	NA	5	0	0	0	6
Nebr:	Omaha[c]	P	NA	5	0	0	0	1
Nev:	Las Vegas[c]	P	NA	2	0	0	0	0
N.H:	Manchester[c]	P	NA	9	0	0	18	19
N.J:	Trenton[c]	P	NA	7	0	0	0	9
N. Mex:	Albuquerque[c]	P	NA	4	0	0	0	0
N.Y.	Buffalo[c]	P	6	7	0	0	12	9
	New York City[c]	P	NA	10	0	0	18	16
	Syracuse[c]	P	NA	7	0	0	0	9
	Albany	P	7	6	0 (4)	0	0 (4)	0
	Buffalo	P	[e]0	[e]0	0	0	0	0
	Massena	P	9	7	0 (2)	0	0 (2)	0
	Newburg	P	5	6	0 (4)	0	0 (4)	0
	New York City	P	14	10	0	0	0	0
	Syracuse	P	7	3	0 (2)	0	0 (2)	0
N.C:	Charlotte[c]	P	NA	11	0 (2)	0	14 (2)	13
N. Dak:	Minot[c]	P	NA	10	0	0	13	14
Ohio:	Cincinnati[c]	P	NA	8	0	0	0	4
	Cleveland[c]	P	NA	9	0	0	12	10
Okla:	Oklahoma City[c]	P	NA	6	0	0	11	6
	Oklahoma City	P	NS		NS		NS	
	Enid	P	NS		NS		NS	
	Tulsa	P	NS		NS		NS	
	Lawton	P	NS		NS		NS	
	Ardmore	P	NS		NS		NS	
Oreg:	Portland[c]	P	5	5	0	0	0	5
	Baker	P	NA	4	[e]0	[e]0	[e]0	5
	Coos Bay	P	NA	6	[e]0	[e]0	[e]0	12
	Eugene	P	NA	3	[e]0	[e]0	[e]0	4
	Medford	P	NA	3	[e]0	[e]0	[e]0	8
	Portland composite	P	NA	0	[e]0	[e]0	NA	8
	Portland local	P	NA	5	[e]0	[e]0	NA	6
	Redmond	P	NA	5	[e]0	[e]0	[e]0	3
	Tillamook	P	NA	7	[e]0	[e]0	[e]0	16
Pa:	Philadelphia[c]	P	NA	9	0	0	12	6
	Pittsburgh[c]	P	NA	11	0	0	12	12
	Dauphin	P	8	7	0	0	15	13
	Erie	P	12	12	0	0	41	27
	Philadelphia	P	11	8	0	0	19	13
	Pittsburgh	P	15	22	0	0	22	20
R. I:	Providence[c]	P	NA	9	0	0	14	16
S. C:	Charleston[c]	P	8	9	0	1	19	19
S. Dak:	Rapid City[c]	P	NA	7	0	0	0	5
Tenn:	Chattanooga[c]	P	NA	9	0	0	15	10
	Memphis[c]	P	NA	9	0	0	0	7
	Chattanooga	P	6	9	0	0	11	14
	Clinton	P	7	12	0 (2)	0	15 (2)	14
	Fayetteville	P	8	12	0 (2)	0	17 (2)	13
	Knoxville	P	5	7	0 (2)	0	17 (2)	10
	Nashville	P	3	7	0	0	14	9
Tex:	Austin[c]	P	NA	2	0	0	0	3
	Dallas[c]	P	NA	6	0	0	0	6
	Amarillo	R	NS	4	NS	0	NS	2
	Corpus Christi	R	3	4	0	0	0	2
	El Paso	R	NS	3	NS	0	NS	3
	Fort Worth	R	NS	5	NS	0	NS	0
	Harlingen	R	NS	3	NS	0	NS	0
	Houston	R	NS	6	NS	0	NS	14
	Lubbock	R	NS	4	NS	0	NS	0
	Midland	R	NS	2	NS	0	NS	0
	San Antonio	R	NS	4	NS	0	NS	0
	Texarkana	R	NS	8	NS	0	NS	0
	Tyler	R	NS	15	NS	0	NS	17
	Uvalde	R	NS	2	NS	0	NS	0
	Wichita Falls	R	5	9	0	0	0	2
Utah:	Salt Lake City[c]	P	NS	4	NS	0	NS	7
Vt:	Burlington[c]	P	NA	8	0	0	20	13
Va:	Norfolk[c]	P	NA	9	0	0	0	8
Wash:	Seattle[c]	P	NA	5	0	0	15	3
	Spokane[c]	P	NA	6	0	0	11	2
	Benton County	R	0	0	0	0	13	5
	Franklin County	R	NS	1	NS	0	NS	3
	Sandpoint, Idaho	R	11	10	0	0	16	20
	Skagit County	R	10	6	0	0	13	8
W. Va:	Charleston[c]	P	NA	8	0	0	0	4
Wisc:	Milwaukee[c]	P	NA	6	0	0	0	11
Wyo:	Laramie[c]	P	NA	5	0	0	0	1

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for November 1970 and 12-month period, December 1969 through November 1970—Continued

Sampling location	Type of sample[a]	Radionuclide concentration (pCi/liter)					
		Strontium-90		Iodine-131		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA:							
Alberta: Calgary	P	NA		NA		18	17
Edmonton	P	NA		NA		17	19
British Columbia: Vancouver	P	NA		NA		22	26
Manitoba: Winnipeg	P	NA		NA		23	27
New Brunswick: Fredericton	P	NA		NA		22	22
Newfoundland: St. John's	P	NA		NA		22	35
Nova Scotia: Halifax	P	NA		NA		25	21
Ontario: Ottawa	P	NA		NA		11	14
Sault Ste. Marie	P	NA		NA		31	32
Ontario: Thunder Bay	P	NA		NA		29	29
Toronto	P	NA		NA		14	10
Windsor	P	NA		NA		13	10
Quebec: Montreal	P	NA		NA		14	18
Quebec	P	NA		NA		26	26
Saskatchewan: Regina	P	NA		NA		16	14
Saskatoon	P	NA		NA		15	14
CENTRAL AND SOUTH AMERICA:							
Colombia: Bogota	P	3	0	0	0	0	0
Chile: Santiago	P	NS	0	NS	0	NS	0
Ecuador: Guayaquil	P	4	0	0	0	0	0
Jamaica: Mandeville	P	NS	5	NS	0	NS	81
Venezuela: Caracas	P	2	2	0	0	0	0
Canal Zone: Cristobal[c]	P	NA	1	0	0	12	9
Puerto Rico: San Juan[c]	P	NA	4	0	0	0	7
PMN network average[f]		8	7	0	0	7	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter; Michigan—14 pCi/liter; Oregon—15 pCi/liter
Cesium-137: Colorado—25 pCi/liter; New York—20 pCi/liter; Oregon—15 pCi/liter
Strontium-90: New York—3 pCi/liter

[f] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].

NA, no analysis.
NS, no sample collected.

in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports.* The relationship between the PMN stations and the State stations is shown in figure 2. The first column under each of the radionuclides reported gives the monthly average for the station and in parentheses, the number of samples analyzed in that month. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than

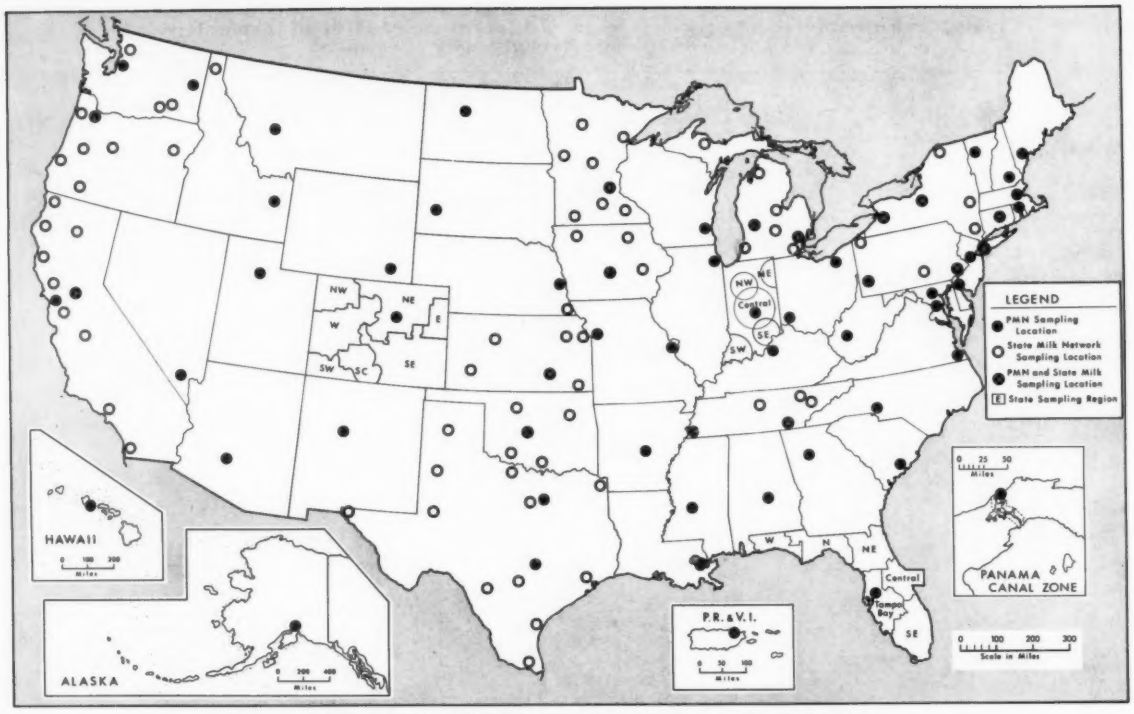

Figure 2. State and PMN milk sampling stations in the United States

the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed populations groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90, iodine-131, and cesium-137 for November 1970 and the 12-month period, December 1969 through November 1970. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for November 1970 were below the respective practical reporting levels. The following station averages reflect samples in which strontium-89 and barium-140 were detected: strontium-89, Kans., Topeka (State) 6 pCi/liter; barium-140 Fla., Southeast (State) 12 pCi/liter.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower guide levels established by the Federal Radiation Council, levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 20 pCi/liter in the United States for November 1970 and the highest 12-month average was 22 pCi/liter (Pittsburgh, Pa., State) representing 11.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 136 pCi/liter in the

United States for November 1970 and the highest 12-month average was 75 pCi/liter (Southeast Florida) representing 2.1 percent of the value derived from the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica. Iodine-131 results for individual samples were all below the practical reporting level with the following exceptions: Florida, Southeast (State), 14 pCi/liter; Kansas, Coffeyville (State), 21 pCi/liter, Falls City (State), 16 pCi/liter, Topeka (State), 19 pCi/liter.

As of July 1, 1970, the collection frequency of the PMN was reduced from weekly to quarterly because of lack of variations in the data. Provisions have been made to increase the collection frequency if warranted by the situation.

Gamma spectroscopy will continue to be performed on all samples. Strontium-89 and strontium-90 analyses will be performed on samples from 12 selected stations each month, and strontium-89 and strontium-90 analyses will be performed on all samples on a quarterly basis. The 12 selected stations are Boston, Mass; Buffalo, N.Y; Chicago, Ill; Charleston, S.C; Little Rock, Ark; New Orleans, La; Tampa, Fla; Idaho Falls, Idaho; Portland, Oreg; Salt Lake City, Utah; Palmer, Alaska; and Honolulu, Hawaii.

Acknowledgement

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Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Air, Occupational and Radiological Health
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Nuclear Engineering
New York State Department of Environmental Conservation

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiological Health Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January–June 1970	November 1970
Carbon-14 and Tritium in Total Diet and Milk	January 1969–June 1970	January 1971
Connecticut Standard Diet	July–December 1969	December 1970
Institutional Diet Samples	July–September 1970	February 1971
Strontium-90 in Tri-City Diets	January–December 1969	June 1970

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (2–4), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	July–December 1968	August 1970
Coast Guard	January 1968–July 1969	February 1970
Interstate Carrier Drinking Water	1967–1969	December 1970
Kansas	January–December 1969	September 1970
Minnesota	January–June 1969	January 1970
North Carolina	January–December 1967	May 1969
New York	January–June 1969	June 1970
Radiostrontium in Tap Water, *HASL*	January–December 1969	July 1970
Tritium in Community Water Supplies	1969	December 1970
Tritium in Surface Waters	January–June 1970	November 1970
Washington	January–June 1969	June 1970

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(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
Fallout in the United States and Other Areas, *HASL*	July 1968–December 1969	January 1971
Plutonium in Airborne Particulates and Precipitation, *PHS*	April–December 1969	October 1970
Surface Air Sampling Program, *HASL*	January–December 1967	January 1971

1. Radiation Alert Network November 1970

Air Pollution Control Office
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of the stations are operated by State Health Department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Data Acquisition and Analysis Branch, Division of Air Quality and Emission Data, EPA, Cincinnati, Ohio. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during November 1970. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, November 1970

Station location		Gross beta radioactivity (5-hour field estimate) (pCi/m³)				Last profile in RHD&R	Precipitation				
		Number of samples	Maximum	Minimum	Average[a]		Number of samples	Total depth (mm)	Field estimation of deposition		
									Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	19	4	0	1	Oct 70	2	41	2	41	2
						Feb 71	0				
Alaska:	Anchorage	0				Nov 70	0				
	Attu Island	30	0	0	0	Mar 71	10	59	10	59	27
	Fairbanks	18	1	0	0	Aug 70	0				
	Juneau	2	[b]27	[b]21	[b]26	Sept 70	0				
	Kodiak	6	0	0	0	Dec 70	0				
	Nome	22	1	0	0	Nov 70	0				
	Point Barrow	0				Aug 70	0				
Ariz:	Phoenix	12	11	2	5						
Ark:	Little Rock	10	2	0	1	Mar 71	0				
Calif:	Berkeley	18	1	0	0	Sept 70	6	144	6	144	3
	Los Angeles	18	6	0	1	Dec 70	0				
C.Z.:	Ancon	0				Sept 70	0				
Colo:	Denver	17	6	0	2	Sept 70	5	25	[c]		
Conn:	Hartford	17	1	0	0	July 70	8	49	8	49	1
Del:	Dover	18	1	0	0	Feb 71	0				
D.C.:	Washington	24	1	0	0	Dec 70	0				
Fla:	Jacksonville	17	2	0	1	Mar 71	2	9	2	9	1
	Miami	10	0	0	0	July 70	1	20	1	20	0
Ga:	Atlanta	16	1	1	1	Jan 71	1	98	1	98	24
Guam:	Agana	0				Feb 71	0				
Hawaii:	Honolulu	23	1	0	0	Nov 70	9	93	[c]		
Idaho:	Boise	19	4	0	1	Nov 70	8	63	8	63	3
Ill:	Springfield	6	2	0	1	Dec 70	0				
Ind:	Indianapolis	17	1	0	0	Jan 71	0				
Iowa:	Iowa City	17	6	0	1	Sept 70	2	16	2	16	0
Kans:	Topeka	18	3	0	1	Mar 71	6	27	6	27	0
Ky:	Frankfort	0				Dec 70	0				
La:	New Orleans	16	1	0	0	Aug 70	5	23	[c]		
Maine:	Augusta	5	2	0	1	Jan 71	2	25	1	[b]	0
Md:	Baltimore	17	2	0	0	July 70	6	54	6	54	0
Mass:	Lawrence	18	1	0	0	Sept 70	8	109	8	109	0
	Winchester	19	1	0	1	Oct 70	7	99	7	99	0
Mich:	Lansing	16	1	0	0	Nov 70	6	47	6	47	6
Minn:	Minneapolis	18	2	0	0	Feb 71	7	148	7	148	16
Miss:	Jackson	14	2	0	0	Aug 70	2	24	2	24	0
Mo:	Jefferson City	18	3	0	1	Jan 71	2	28	2	28	0
Mont:	Helena	15	3	0	1	Oct 70	3	12	3	12	0
Nebr:	Lincoln	11	5	1	2	Jan 71	1	4	1	4	1
Nev:	Las Vegas	17	3	1	2	July 70	0				
N.H.:	Concord	0				Dec 70	0				
N.J.:	Trenton	17	1	0	0	Aug 70	9	122	9	122	1
N.Mex:	Santa Fe	16	3	0	1	Oct 70	2	5	2	5	0
N.Y.:	Albany	10	2	0	0	Jan 71	1	23	1	23	7
	Buffalo	16	1	0	0	Sept 70	0				
	New York City	0				Oct 70	0				
N.C.:	Gastonia	13	12	1	4	Sept 70	2	17	[c]		
N. Dak:	Bismarck	18	4	0	1	Dec 70	8	31	8	31	3
Ohio:	Cincinnati	0				Feb 71	0				
	Columbus	1	1	1	1	Aug 70	0				
	Painesville	19	1	0	1	July 70	6	64	6	64	16
Okla:	Oklahoma City	16	4	1	2	Nov 70	1	8	1	8	0
	Ponca City	18	15	1	3	July 70	0				
Oreg:	Portland	18	2	0	0	Jan 71	13	154	13	154	5
Pa:	Harrisburg	10	1	0	0	Feb 71	2	31	2	31	3
P.R.:	San Juan	0				Aug 70	0				
R.I.:	Providence	18	1	0	0	Nov 70	4	30	4	30	1
S.C:	Columbia	16	4	0	1	Oct 70	3	124	1	11	0
S. Dak:	Pierre	18	6	0	2	Aug 70	0				
Tenn:	Nashville	17	1	0	0	Nov 70	4	55	4	55	1
Tex:	Austin	0				Feb 71	0				
	El Paso	0				Dec 70	0				
Utah:	Salt Lake City	29	4	0	1	Jan 71	9	58	8	48	8
Vt:	Barre	12	4	0	1	Mar 71	4	39	4	39	6
Va:	Richmond	18	1	0	0	Mar 71	8	115	8	115	44
Wash:	Seattle	10	0	0	0	Mar 71	8	82	[c]		
	Spokane	11	1	0	1	Feb 71	0				
W. Va:	Charleston	18	2	0	1	Oct 70	8	93	8	93	18
Wisc:	Madison	20	2	0	1	Mar 71	6	33	6	33	2
Wyo:	Cheyenne	18	4	0	1	July 70	1	3	1	3	0
Network summary		935	27	0	1		210	62	5	52	5

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] These data are suspect.
[c] This station is part of the plutonium in precipitation network. No gross beta measurements are done.

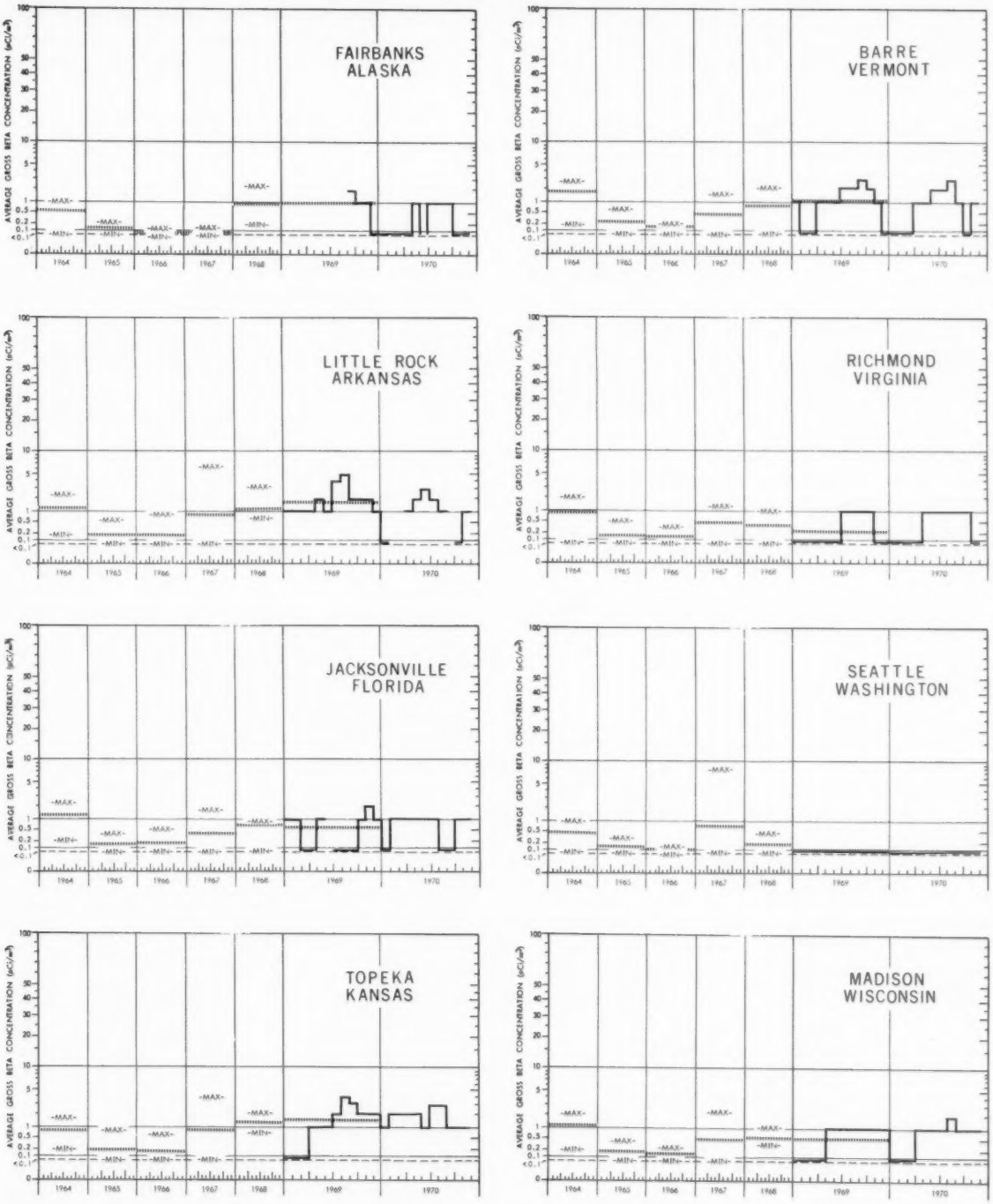

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1964–November 1970

2. Canadian Air and Precipitation Monitoring Program[1], November 1970

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for November 1970 are presented in table 2.

[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, November 1970

Station	Number of samples	Air surveillance, gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	2	0.1	0.0	0.1	225	3.82
Coral Harbour	3	.1	.0	.1	7	.12
Edmonton	5	.1	.0	.1	16	.58
Ft. Churchill	5	.1	.0	.1	8	.47
Fredericton	5	.1	.1	.1	20	1.32
Goose Bay	6	.1	.0	.0	23	.83
Halifax	5	.1	.0	.1	28	2.94
Inuvik	4	.1	.1	.1	17	.25
Montreal	4	.1	.1	.1	34	2.58
Moosonee	5	.1	.1	.1	NS	NS
Ottawa	5	.1	.0	.1	24	2.05
Quebec	1	.0	.0	.0	43	4.41
Regina	9	.2	.0	.1	34	.62
Resolute	5	.2	.0	.1	NS	NS
St. John's, Nfld.	5	.1	.0	.1	12	2.31
Saskatoon	5	.1	.0	.1	46	1.14
Sault Ste. Marie	5	.2	.0	.1	45	2.24
Thunder Bay	5	.2	.0	.1	24	2.05
Toronto	1	.1	.1	.1	43	1.98
Vancouver	5	.1	.0	.0	32	3.22
Whitehorse	5	.3	.1	.1	NS	NS
Windsor	5	.2	.1	.1	19	1.30
Winnipeg	5	.2	.0	.1	63	1.69
Yellowknife	5	.1	.0	.1	95	.72
Network summary	110	0.3	0.0	0.1	41	1.74

NS, no sample.

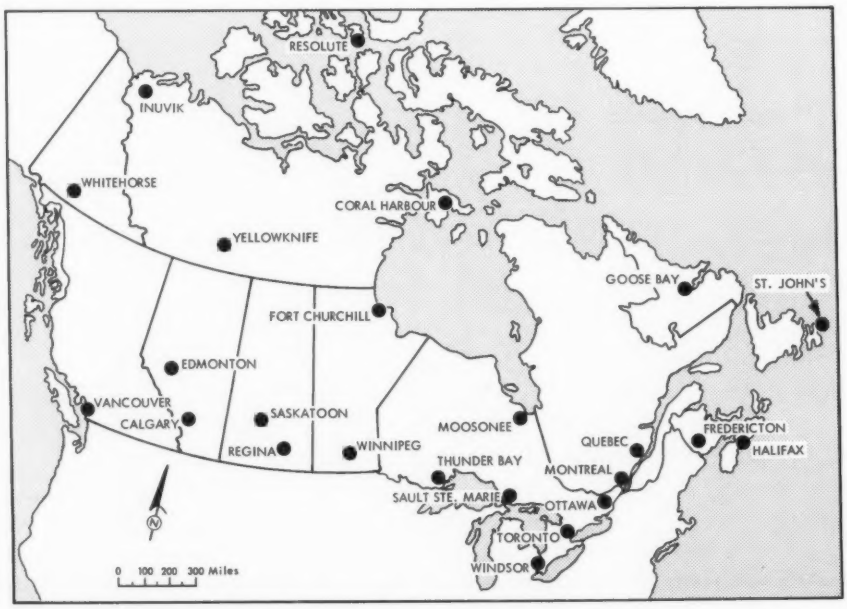

Figure 3. Canadian air and precipitation sampling stations

3. Pan American Air Sampling Program November 1970

Pan American Health Organization and
U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 4. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The November 1970 air monitoring results from the participating countries are given in table 3.

Table 3. Summary of gross beta radioactivity in Pan American surface air, November 1970

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Argentina: Buenos Aires	0	NS	NS	NS
Bolivia: La Paz	18	1.10	0.10	0.35
Chile: Santiago	15	.40	.05	.23
Colombia: Bogota	19	.04	.01	.02
Ecuador: Cuenca	0	NS	NS	NS
Guayaquil	0	NS	NS	NS
Quito	0	NS	NS	NS
Guyana: Georgetown	8	.11	.01	.04
Jamaica: Kingston	0	NS	NS	NS
Peru: Lima	24	.57	.21	.38
Venezuela: Caracas	11	.10	.02	.06
West Indies: Trinidad	18	.10	.00	.06
Pan American summary	113	1.10	0.00	0.19

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.
NS, no sample.

Figure 4. Pan American Air Sampling Program stations

4. Plutonium in Airborne Particulates January–June 1970

Radiation Office
Environmental Protection Agency

The Radiation Alert Network (RAN) of the Air Pollution Control Office, Environmental Protection Agency, routinely collects airborne particulate samples from 11 selected RAN stations for plutonium analyses. The plutonium analyses were initiated in November 1965 and references to the previous results through December 1969 have been published (*6*).

One-half of each individual air filter from the selected stations is sent to the Northeastern Radiological Health Laboratory, Winchester, Mass. The laboratory analyzes a composite of these samples for each station on a quarterly basis. The results for January-June 1970 are presented in table 4. The minimum detectable activities are 20 fCi and 15 fCi per sample for plutonium-238 and plutonium-239, respectively. The volume of air samples varies, generally ranging from 20,000 to 30,000 cubic meters per month.

Table 4. Plutonium in airborne particulates, January–June 1970

1970	Anchorage	Phoenix	Denver	Honolulu	New Orleans	Rockville	Buffalo	Gastonia	Pierre	Austin	Seattle
Plutonium-238: (aCi/m³)											
January–March	3	10	9	8	5	5	NS	6	4	7	4
April–June	[a] 6	20	16	5	9	7	10	12	9	11	8
Plutonium-239: (aCi/m³)											
January–March	20	68	55	40	35	26	NS	45	34	42	31
April–June	21	190	130	50	87	82	89	120	95	110	54
$^{239}Pu/^{238}Pu$:											
January–March	6.7	6.8	6.1	5.0	7.0	5.2	—	7.5	8.5	6.0	7.8
April–June	3.5	9.5	8.1	10.0	9.7	11.7	8.9	10.0	10.6	10.0	6.8

[a] Composite for May and June only.
NS, no sample.

REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*6*) BUREAU OF RADIOLOGICAL HEALTH. Plutonium of airborne particulates, April–December 1969. Radiol Health Data Rep 11:552–553 (October 1970).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Feed Materials Production Center and Paducah Plant.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Feed Materials Production Center January–June 1970

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the Atomic Energy Commission (AEC). The location as related to populated areas is shown in figure 1. Cincinnati and Hamilton, the larger nearby communities, are situated 20 and 10 miles from FMPC, respectively. Operations at this project are concerned with the processing of high-grade uranium concentrates into metallic uranium. These processes include acid digestion of the concentrates, organic phase extraction of uranyl nitrate, subsequent conversion of the uranyl nitrate to uranium oxide and tetrafluoride, reduction to uranium metal, and fabrication of the metal into fuel elements.

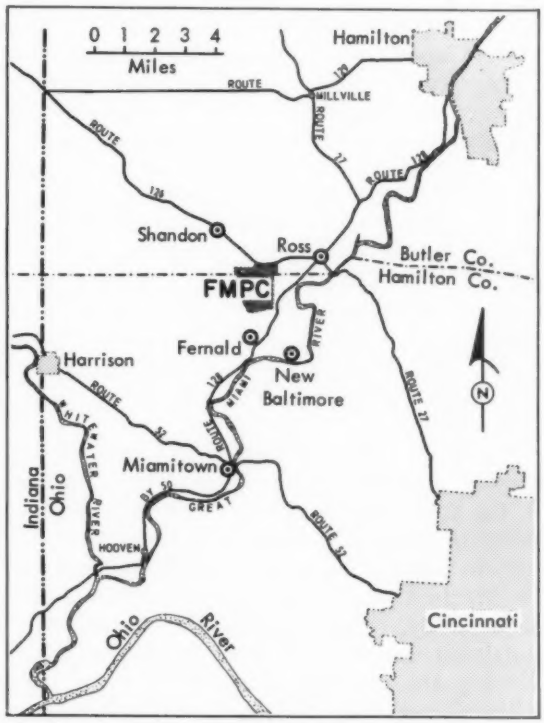

Figure 1. Area map of Feed Materials Production Center

[2] Summarized from "Feed Materials Production Center Environmental Monitoring Semiannual Report for the First Half of 1970" (NLCO–1073).

Table 1. Radioactivity levels of airborne particulates, Feed Materials Production Center, January–June 1970

Location	Number of samples	Uranium concentration[a] (pCi/m³)			Alpha radioactivity[b] (pCi/m³)			Beta radioactivity[c] (pCi/m³)		
		Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Onsite:										
Southwest	26	0.9	<0.1	0.1	0.9	<0.1	0.2	1.4	<0.1	0.7
Northwest	26	.1	< .1	< .1	.1	< .1	< .1	.4	< .1	.1
Northeast	26	.3	< .1	< .1	.3	< .1	< .1	.7	< .1	.2
Southeast	26	.1	< .1	< .1	.1	< .1	< .1	.4	< .1	.1
All onsite samples	104			0.1			0.1			0.3
Offsite:										
0–2 miles from FMPC	12	<0.1	< .1	< .1	<0.1	< .1	<0.1	0.2	<0.1	<0.1
2–4 miles from FMPC	12	< .1	< .1	< .1	< .1	< .1	< .1	.2	< .1	< .1
4–8 miles from FMPC	17	< .1	< .1	< .1	< .1	< .1	< .1	.4	< .1	.1
8–12 miles from FMPC	4	.1	< .1	< .1	.1	< .1	< .1	.6	.6	.6
All offsite samples	45			<0.1			<0.1			0.1

[a] AEC radiation protection standard—2 pCi/m³.
[b] AEC radiation protection standard—2 pCi/m³.
[c] AEC radiation protection standard—1 nCi/m³ (thorium-234).

During the past 2 years, the project has also processed thorium to produce purified oxide and metal. The process of these products is essentially the same as used in producing uranium.

During the many involved reactions and processes that lead to the production of reactor fuels, various liquid and airborne wastes are generated. These wastes contain varying quantities of uranium and thorium. Various in-plant methods are used to curtail their release into the environment surrounding the plant. Almost complete removal of the materials is accomplished by using dust collectors and waste treatment processes. An environmental monitoring program has been established to determine the concentrations of plant materials in the water and air outside the project.

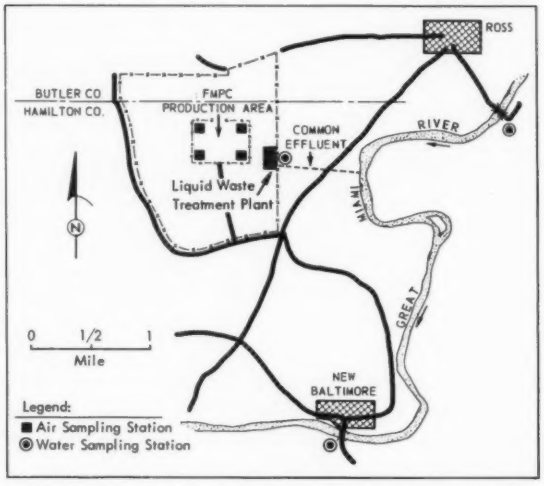

Figure 2. Air and water sampling stations, FMPC

Air monitoring

Onsite air samples are obtained from four permanent perimeter air sampling stations, located at the four corners of the production area as shown in figure 2. Samples from these perimeter stations are collected once each week and analyzed for uranium and gross alpha and gross beta radioactivity. Offsite samples are collected by a mobile air sampling unit. The location at which samples are collected is determined by local meteorological conditions on the day of sampling. Approximately 80 percent of all samples are taken downwind of the FMPC plant. Replicate samples are taken at each sampling point and averaged to obtain a representative concentration for that location. An analysis for thorium is not considered necessary because of the small amount of thorium handled in the project. Concentrations of uranium and alpha and beta radioactivity of airborne particulates sampled at onsite and offsite locations are given in table 1.

The results of sampling indicate that the concentrations at onsite locations averaged 5 per-

cent, 5 percent, and 0.02 percent of the AEC standards for uranium, alpha radioactivity, and beta radioactivity, respectively; the offsite concentrations averaged 5 percent, 5 percent, and 0.01 percent of the AEC standards for uranium, alpha radioactivity, and beta radioactivity.

Water monitoring

Each of the individual production plants on the project has collection sumps and treatment equipment to remove the uranium from the process wastewater. The effluents from the plants are collected at a general sump for additional treatment and settling. The clear water from the sump is pumped to the river. The solid portion is pumped to a chemical waste pit for further settling. The clear effluent from the pit is then combined with three other types of project wastewater and discharged via a common effluent outfall into the Great Miami River. A Parshal-Flume-type water sampler collects samples of the combined effluent stream, which are removed and analyzed daily. These results are utilized with measurements of river flow in calculating the radioactive contaminant concentrations added to the river. Weekly spot samples are obtained upstream; a continuous sample is taken for a 24-hour period downstream, and at least one sample is analyzed each week. Samples of the storm sewer overflow are collected in an automatic flow integrated sampler when overflow occurs. All samples are analyzed for uranium, gross alpha, and gross beta radioactivity and radium-228, a daughter of thorium-232. Since radium-228 has the most restrictive AEC standard, control of this radionuclide and of the gross radioactivity insures that the AEC standards for the thorium decay chain are not exceeded.

The average concentrations of all sampled contaminants at the downstream position indicate that each contaminant was well below the AEC standard. It may be concluded from sampling and calculations that the FMPC effluent produced little change in the river's quality. The results of the FMPC water monitoring program for January–June 1970 are summarized in table 2.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1969	March 1970
July–December 1969	August 1970

Table 2. Radioactivity in the Great Miami River, Feed Materials Production Center, January–June 1970

Location	Number of samples	Uranium[a] (pCi/liter)			Alpha radioactivity[b] (pCi/liter)			Beta radioactivity[b] (pCi/liter)			Number of samples	Radium-228[c] (pCi/liter)		
		Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average		Maximum	Minimum	Average
Sewer outfall[d]	181	<10	<10	<10	<10	<10	<10	20	<10	<10	9	1.01	.10	.39
Upstream from outfall	27	50	<10	<10	60	<10	10	50	<10	20	6	9.10	.45	2.86
Downstream from outfall	27	40	<10	<10	50	<10	<10	60	<10	20	6	1.36	.45	1.04

[a] AEC standard—20 nCi/liter.
[b] AEC standard—3 nCi/liter.
[c] AEC standard—30 pCi/liter.
[d] Concentrations in the river as calculated from sewer outfall sample results.

2. Paducah Plant[3] January–June 1970

Union Carbide Corporation
Paducah, Ky.

The Paducah Plant is a government-owned gaseous diffusion plant operated by the Nuclear Division of the Union Carbide Corporation for the Atomic Energy Commission. The diffusion plant processes large quantities of relatively pure uranium compounds. The uranium hexafluoride manufacturing plant, a former source of diffusion plant feed which was placed on standby in June of 1964, was reactivated in August 1968. Parts of the associated uranium metal foundry, usually on standby, are operated infrequently as the need arises. A decontamination and uranium recovery facility operates to prepare equipment for repair and to recover impure or scrap uranium materials. Depleted uranium metal is fabricated into shields, weights, ballasts, or other shapes on a nonroutine basis. The major sources of external penetrating radiation are the daughter products of uranium, thorium-234 and protactinium-234, which may be concentrated by uranium recovery processes or by uranium hexafluoride vaporization. The element uranium can be a physiological hazard only if allowed to enter the body. The chemical toxicity of the uranium processed at the Paducah Plant overshadows any probable biological effects of radiation from this element, thus making it comparable as a physiological hazard to lead, mercury, or other well-known heavy metals.

The uranium enrichment areas (cascade) operate with a very low loss of material. Millions of pounds of uranium hexafluoride may be fed to, diffused in, and withdrawn from the cascade with the loss of only a few pounds per year. There is a slight loss of uranium to the atmosphere when diluent gases are purged from equipment units or from the cascade. Some uranium on cascade equipment replaced for maintenance or modification is removed in the decontamination facility.

Effluents from the uranium hexafluoride manufacturing plant are more significant than those of the diffusion cascade. The transfer of powdered uranium salts between the numerous processing reactors and intermediate storage facilities requires extensive use of vacuum or local exhaust systems. Various bag and pleated filter units are used to remove uranium from exhaust air. The product uranium hexafluoride is separated from entrained solids, excess fluorine, and diluent gases by a series of filters, cold condensers, and fluid bed absorbers. A small fraction of the input to this plant constituting a significant amount of uranium is not reacted to uranium hexafluoride

[3] Summarized from "Environmental Concentrations of Radioactive Materials near the Paducah Plant—Report for the First Half of 1970."

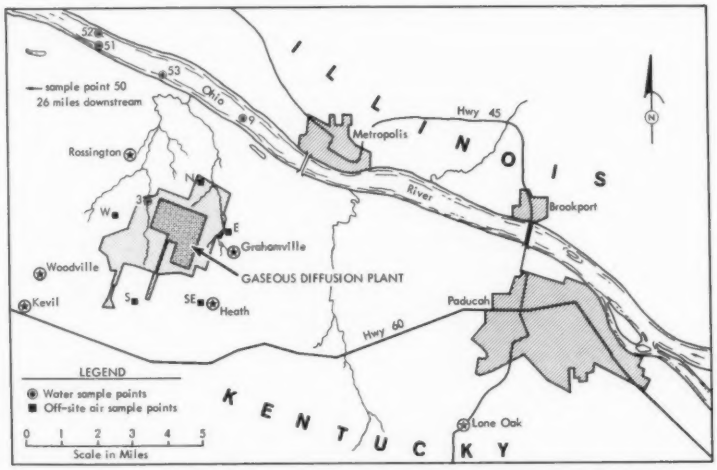

Figure 3. Sampling locations, Paducah Gaseous Diffusion Plant

and must be processed through uranium recovery at the decontamination facility. Beta emitting uranium decay products which separate from the uranium hexafluoride at fluorination are also in this material flow.

The environmental monitoring program provides for continuously sampling the air at four stations around the plant perimeter fence, and at five stations located approximately 1 mile outside this fence (figure 3). Big Bayou and Little Bayou waters are sampled continuously, and grab samples are collected at five locations in the Ohio River. In addition, gamma radiation readings are taken each month at each of the air sampling stations with a Geiger-Mueller type meter 3 feet above ground level.

Table 3. Uranium concentrations in outdoor air samples, Paducah Plant, January–June 1970

Sample location[a]	Number of samples	Uranium alpha radioactivity[b] (pCi/m³)		
		Maximum	Minimum[c]	Mean[d]
At plant perimeter fence:				
North	26	0.08	<0.02	0.02
East	26	.29	< .02	.04
South	26	.02	< .02	< .02
West	26	.05	< .02	< .02
Summary	104	0.29	<0.02	0.02
About 1 mile outside plant perimeter fence:				
North	26	0.02	0.02	<0.02
East	26	.04	< .02	< .02
South	26	.02	< .02	< .02
West	26	.02	< .02	< .02
Southeast	26	.02	< .02	< .02
Summary	130	0.04	<0.02	<0.02

[a] See figure 3.
[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57×10^4 alpha dis/s.
[c] The minimum detectable concentration of uranium in air is 0.02 pCi/m³.
[d] The AEC standard for natural uranium in air released to the environs beyond a controlled area is 2 pCi/m³.

Basic standards

The radiation protection standards observed for the in-plant work environment of employees and for offsite exposure of the general population are those contained in Appendix 0524 of the AEC manual.

Discussion

Data summarizing the environmental concentrations of radioactive materials in air and water and the gamma radiation levels in the vicinity

Table 4. Beta radioactivity in outdoor air samples Paducah Plant, January–June 1970

Sample locations[a]	Number of samples	Beta radioactivity (pCi/m³)		
		Maximum	Minimum[b]	Mean[c]
At plant perimeter fence:				
North	26	3.3	<0.1	0.86
East	26	1.5	< .1	.45
South	26	.63	< .1	.20
West	26	.86	< .1	.47
Summary	104	3.3	<0.1	0.47
About 1 mile outside plant perimeter fence:				
North	26	1.2	<0.1	0.27
East	26	.72	< .1	.23
South	26	.77	< .1	.23
West	26	.63	< .1	.23
Southeast	26	.72	< .1	.24
Summary	130	1.2	<0.1	0.24

[a] See figure 3.
[b] The minimum detectable amount of beta-particle emitters in air is 0.1 pCi/m³.
[c] The AEC standard for immediate daughter products of uranium in air is 1 nCi/m³ (standard for thorium-234).

Table 5. Concentrations of uranium in water, Paducah Plant, January–June 1970

Sample locations[a]	Number of samples	Uranium[b] (pCi/liter)		
		Maximum	Minimum[c]	Mean[d]
Big Bayou 3	26	31	1	8
Little Bayou 17	26	280	13	56
Ohio River 9	4	<1	<1	<1
Composite of 50, 51, 52 and 53	4	2	<1	<1

[a] See figure 3.
[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57×10^4 alpha dis/s.
[c] The minimum detectable concentration of uranium in water is 1 pCi/liter.
[d] The AEC standard for natural uranium in water beyond a controlled area is 20 nCi/liter.

Table 6. Concentration of beta-particle emitters in water, Paducah Plant, January–June 1970

Sample locations[a]	Number of samples	Beta-particle emitters (pCi/liter)		
		Maximum	Minimum[b]	Mean[c]
Big Bayou 3	26	300	<100	<100
Little Bayou 17	26	8,200	<100	1,000
Ohio River 9	4	400	<100	100
Composite of 50, 51, 52 and 53	4	200	100	<100

[a] See figure 3.
[b] The minimum detectable amount of beta-particle emitters in water is 100 pCi/liter.
[c] The AEC standard for the immediate daughter products of uranium in water beyond a controlled area is 20 nCi/liter.

Table 7. External gamma radiation levels January–June 1970

Sample locations[a]	Number of readings	Average gamma radiation (mR/h)
At plant perimeter fence:		
North	5	0.02
East[b]	5	.04
South	5	.02
West	5	.02
Total	20	0.02
About 1 mile outside plant perimeter fence:		
North	5	0.02
East	5	.02
South	5	.02
West	5	.02
Southeast	5	.02
Total	25	0.02

[a] See figure 3.
[b] Near uranium hexafluoride cylinder storage area.

of the Paducah Gaseous Diffusion Plant are presented in tables 3 through 7.

Air samples were collected continuously at each of the four stations at the plant perimeter fence and at five stations about 1 mile outside the plant. Air is filtered at 0.3 cfm through 2-inch diameter membrane filters which are replaced weekly and counted for alpha and beta radioactivity.

The average alpha particle count—interpreted as uranium, the most likely source of radioactivity—of the 234 air samples collected during January–June 1970 was 1.0 percent of the AEC standard set for individuals residing in the vicinity of a controlled area. The average beta particle count of the same samples was 0.04 percent of the AEC standard.

The average uranium analyses of weekly water samples collected continuously from Big and Little Bayous during January–June 1970 were 0.04 and 0.28 percent, respectively, of the AEC standard for water beyond a controlled area. The average result of the uranium analyses for each of the 5 grab samples collected at monthly intervals from the Ohio River below the plant was less than 0.01 percent of the AEC standard.

The concentration of beta-particle emitters in the Big and Little Bayous averaged less than 0.5 percent and 5 percent, respectively, of the AEC standard for the decay products of uranium-238 during the January–June 1970 period. The average beta radioactivity of the Ohio River was less than 0.5 percent of the standard for uranium-238 decay products.

External gamma radiation in the vicinity of the Paducah Plant averaged 0.02 mR/h at all sampling stations for January–June 1970, except for the east plant perimeter station which had an average of 0.04 mR/h.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–June 1969	April 1970
July–December 1969	September 1970

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
ALABAMA				
Decatur	Browns Ferry Nuclear Power Plant: Unit 1	1,064,500	Tennessee Valley Authority	1972
Decatur	Browns Ferry Nuclear Power Plant: Unit 2	1,064,500	Tennessee Valley Authority	1972
Decatur	Browns Ferry Nuclear Power Plant: Unit 3	1,064,500	Tennessee Valley Authority	1973
Dothan	Joseph M. Farley Nuclear Plant: Unit 1	829,000	Alabama Power Co.	1975
Dothan	Joseph M. Farley Nuclear Plant: Unit 2	829,000	Alabama Power Co.	1977
ARKANSAS				
London	Arkansas Nuclear One: Unit 1	820,000	Arkansas Power & Light Co.	1973
London	Arkansas Nuclear One: Unit 2	950,000	Arkansas Power & Light Co.	1975
CALIFORNIA				
Humboldt Bay	Humbolt Bay Power Plant: Unit 3	68,500	Pacific Gas & Electric Co.	1963
San Clemente	San Onofre Nuclear Generating Station: Unit 1	430,000	So. Calif. Ed. & San Diego Gas & El. Co.	1967
San Clemente	San Onofre Nuclear Generating Station: Unit 2	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1975
San Clemente	San Onofre Nuclear Generating Station: Unit 3	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1977
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 1	1,060,000	Pacific Gas & Electric Co.	1973
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 2	1,060,000	Pacific Gas & Electric Co.	1974
Clay Station	Rancho Seco Nuclear Generating Station	804,000	Sacramento Municipal Utility District	1972
COLORADO				
Platteville	Ft. St. Vrain Nuclear Generating Station	330,000	Public Service Co. of Colorado	1972
CONNECTICUT				
Haddam Neck	Haddam Neck Plant	575,000	Conn. Yankee Atomic Power Co.	1967
Waterford	Millstone Nuclear Power Station: Unit 1	652,100	Northeast Utilities	1970
Waterford	Millstone Nuclear Power Station: Unit 2	828,000	Northeast Utilities	1974
FLORIDA				
Turkey Point	Turkey Point Station: Unit 3	651,500	Florida Power & Light Co.	1971
Turkey Point	Turkey Point Station: Unit 4	651,500	Florida Power & Light Co.	1972
Red Level	Crystal River Plant: Unit 3	858,000	Florida Power Corp.	1972
Ft. Pierce	Hutchinson Island: Unit 1	813,000	Florida Power and Light Co.	1973
GEORGIA				
Baxley	Edwin I. Hatch Nuclear Plant: Unit 1	786,000	Georgia Power Co.	1973
Baxley	Edwin I. Hatch Nuclear Plant: Unit 2	786,000	Georgia Power Co.	1976
ILLINOIS				
Morris	Dresden Nuclear Power Station: Unit 1	200,000	Commonwealth Edison Co.	1960
Morris	Dresden Nuclear Power Station: Unit 2	809,000	Commonwealth Edison Co.	1970
Morris	Dresden Nuclear Power Station: Unit 3	809,000	Commonwealth Edison Co.	1971
Zion	Zion Nuclear Plant: Unit 1	1,050,000	Commonwealth Edison Co	1972
Zion	Zion Nuclear Plant: Unit 2	1,050,000	Commonwealth Edison Co.	1973
Cordova	Quad-Cities Station: Unit 1	809,000	Comm. Ed. Co.–Ia.–Ill. Gas & Elec. Co	1971
Cordova	Quad-Cities Station: Unit 2	809,000	Comm. Ed. Co.–Ia.–Ill. Gas & Elec. Co.	1972
Seneca	LaSalle Co. Nuclear Station: Unit 1	1,078,000	Comm. Ed. Co.–Ia.	1975
Seneca	LaSalle Co. Nuclear Station: Unit 2	1,078,000	Comm. Ed. Co.–Ia.	1976
INDIANA				
Dune Acres	Bailly Generating Station	660,000	Northern Indiana Public Service Co.	1976
IOWA				
Cedar Rapids	Duane Arnold Energy Center: Unit 1	545,000	Iowa Electric Light and Power Co.	1973
LOUISIANA				
Taft	Waterford Generating Station: Unit 3	1,165,000	Louisiana Power & Light Co.	1976
MAINE				
Wiscasset	Maine Yankee Atomic Power Plant	790,000	Maine Yankee Atomic Power Co.	1972
MARYLAND				
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 1	800,000	Baltimore Gas and Electric Co.	1973
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 2	800,000	Baltimore Gas and Electric Co.	1974
MASSACHUSETTS				
Rowe	Yankee Nuclear Power Station	175,000	Yankee Atomic Electric Co.	1961
Plymouth	Pilgrim Station	654,000	Boston Edison Co.	1971
MICHIGAN				
Big Rock Point	Big Rock Point Nuclear Plant	70,300	Consumers Power Co.	1963
South Haven	Palisades Nuclear Power Station	700,000	Consumers Power Co.	1970
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 1	60,900	Detroit Edison Co.	1970
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 2	1,123,000	Detroit Edison Co.	1973
Bridgman	Donald C. Cook Plant: Unit 1	1,054,000	Indiana & Michigan Electric Co.	1973
Bridgman	Donald C. Cook Plant: Unit 2	1,060,000	Indiana & Michigan Electric Co.	1974
Midland	Midland Nuclear Power Plant: Unit 1	492,000	Consumers Power Co.	1974
Midland	Midland Nuclear Power Plant: Unit 2	818,000	Consumers Power Co.	1975
MINNESOTA				
Monticello	Monticello Nuclear Generating Plant	545,000	Northern States Power Co.	1970
Red Wing	Prairie Island Nuclear Generating Plant: Unit 1	530,000	Northern States Power Co.	1972
Red Wing	Prairie Island Nuclear Generating Plant: Unit 2	530,000	Northern States Power Co.	1974
*	—	1,201,000	Tennessee Valley Authority	1977
*	—	1,201,000	Tennessee Valley Authority	1978

* Site not selected.

Figure 1. Nuclear power plants in the United States

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
NEBRASKA				
Fort Calhoun	Ft. Calhoun Station: Unit 1	457,400	Omaha Public Power District	1972
Brownville	Cooper Nuclear Station	778,000	Nebraska Public Power District and Iowa Power and Light Co.	1972
NEW JERSEY				
Toms River	Oyster Creek Nuclear Power Plant: Unit 1	560,000	Jersey Central Power & Light Co.	1969
Lacey Township	Forked River Generating Station: Unit 1	1,140,000	Jersey Central Power & Light Co.	1975
Salem	Salem Nuclear Generating Station: Unit 1	1,050,000	Public Service Electric and Gas, N. J.	1972
Salem	Salem Nuclear Generating Station: Unit 2	1,050,000	Public Service Electric and Gas, N. J.	1973
Newbold Island	Newbold Nuclear Generating Station: Unit 1	1,088,000	Public Service Electric and Gas, N. J.	1975
Newbold Island	Newbold Nuclear Generating Station: Unit 2	1,088,000	Public Service Electric and Gas, N. J.	1977
NEW YORK				
Indian Point	Indian Point Station: Unit 1	265,000	Consolidated Edison Co.	1963
Indian Point	Indian Point Station: Unit 2	873,000	Consolidated Edison Co.	1971
Indian Point	Indian Point Station: Unit 3	965,000	Consolidated Edison Co.	1973
Scriba	Nine Mile Point Nuclear Station	500,000	Niagara Mohawk Power Co.	1970
Rochester	R.E.Ginna Nuclear Power Plant: Unit 1	420,000	Rochester Gas & Electric Co.	1970
Brookhaven	Shoreham Nuclear Power Station	819,000	Long Island Lighting Co.	1975
Lansing	Bell Station	838,000	New York State Electric & Gas Co.	1978
Verplanck	Verplanck: Unit 1	1,115,000	Consolidated Edison Co.	1977
Scriba	James A. Fitzpatrick Nuclear Power Plant	821,000	Power Authority of State of N.Y.	1973
NORTH CAROLINA				
Southport	Brunswick Steam Electric Plant: Unit 1	821,000	Carolina Power and Light Co.	1976
Southport	Brunswick Steam Electric Plant: Unit 2	821,000	Carolina Power and Light Co.	1974
*		821,000	Carolina Power and Light Co.	—
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 1	1,150,000	Duke Power Co.	1975
Cownas Ford Dam	Wm. B. McGuire Nuclear Station: Unit 2	1,150,000	Duke Power Co.	1976
OHIO				
Oak Harbor	Davis-Besse Nuclear Power Station	872,000	Toledo Edison-Cleveland Electric Illuminating Co.	1974
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 1	810,000	Cincinnati Gas & Electric Co.	1974
OREGON				
Rainier	Trojan Station	1,130,000	Portland General Electric Co.	1974
PENNSYLVANIA				
Peach Bottom	Peach Bottom Atomic Power Station: Unit 1	40,000	Philadelphia Electric Co.	1967
Peach Bottom	Peach Bottom Atomic Power Station: Unit 2	1,065,000	Philadelphia Electric Co.	1972
Peach Bottom	Peach Bottom Atomic Power Station: Unit 3	1,065,000	Philadelphia Electric Co.	1973
Pottstown	Limerick Generating Station: Unit 1	1,065,000	Philadelphia Electric Co.	1975
Pottstown	Limerick Generating Station: Unit 2	1,065,000	Philadelphia Electric Co.	1977
Shippingport	Shippingport Atomic Power Station: Unit 1	90,000	Duquesne Light Co.	1957
Shippingport	Beaver Valley Power Station: Unit 1	847,000	Duquesne Light Co.-Ohio Edison Co.	1973
Middletown	Three Mile Island Nuclear Station: Unit 1	810,000	Metropolitan Edison Co.	1972
Middletown	Three Mile Island Nuclear Station: Unit 2	810,000	Jersey Central Power & Light Co.	1974
Berwick	Susquehanna Steam Electric Station: Unit 1	1,052,000	Pennsylvania Power and Light	1977
Berwick	Susquehanna Steam Electric Station: Unit 2	1,052,000	Pennsylvania Power and Light	1979
SOUTH CAROLINA				
Hartsville	H.B.Robinson S.E.Plant: Unit 2	700,000	Carolina Power & Light Co.	1971
Seneca	Oconee Nuclear Station: Unit 1	841,000	Duke Power Co.	1971
Seneca	Oconee Nuclear Station: Unit 2	886,000	Duke Power Co.	1972
Seneca	Oconee Nuclear Station: Unit 3	886,000	Duke Power Co.	1973
TENNESSEE				
Daisy	Sequoyah Nuclear Power Plant: Unit 1	1,124,000	Tennessee Valley Authority	1974
Daisy	Sequoyah Nuclear Power Plant: Unit 2	1,124,000	Tennessee Valley Authority	1974
Rhea County	Watts Bar Nuclear Plant: Unit 1	1,170,000	Tennessee Valley Authority	1976
Rhea County	Watts Bar Nuclear Plant: Unit 2	1,170,000	Tennessee Valley Authority	1977
VERMONT				
Vernon	Vermont Yankee Generating Station	513,900	Vermont Yankee Nuclear Power Corp.-Green Mt. Power Corp.	1971
VIRGINIA				
Gravel Neck	Surry Power Station: Unit 1	780,000	Virginia Electric & Power Co.	1971
Gravel Neck	Surry Power Station: Unit 2	780,000	Virginia Electric & Power Co.	1972
Mineral	North Anna Power Station: Unit 1	845,000	Virginia Electric & Power Co.	1974
Mineral	North Anna Power Station: Unit 2	845,000	Vriginia Electric & Power Co.	1975
WASHINGTON				
Richland	N-Reactor/WPPSS Steam	790,000	Washington Public Power Supply System	1966
WISCONSIN				
Genoa	LaCrosse Boiling Water Reactor	50,000	Dairyland Power Cooperative	1969
Two Creeks	Point Beach Nuclear Plant: Unit 1	497,000	Wisconsin Michigan Power Co.	1970
Two Creeks	Point Beach Nuclear Plant: Unit 2	497,000	Wisconsin Michigan Power Co.	1971
Carlton	Kewaunee Nuclear Power Plant: Unit 1	527,000	Wisconsin Public Service Co.	1972
PUERTO RICO				
Central Aguirre	Aguirre Nuclear Power Plant	583,000	Puerto Rico Water Resources Authority	1975

Figure 1. Nuclear power plants in the United States—continued

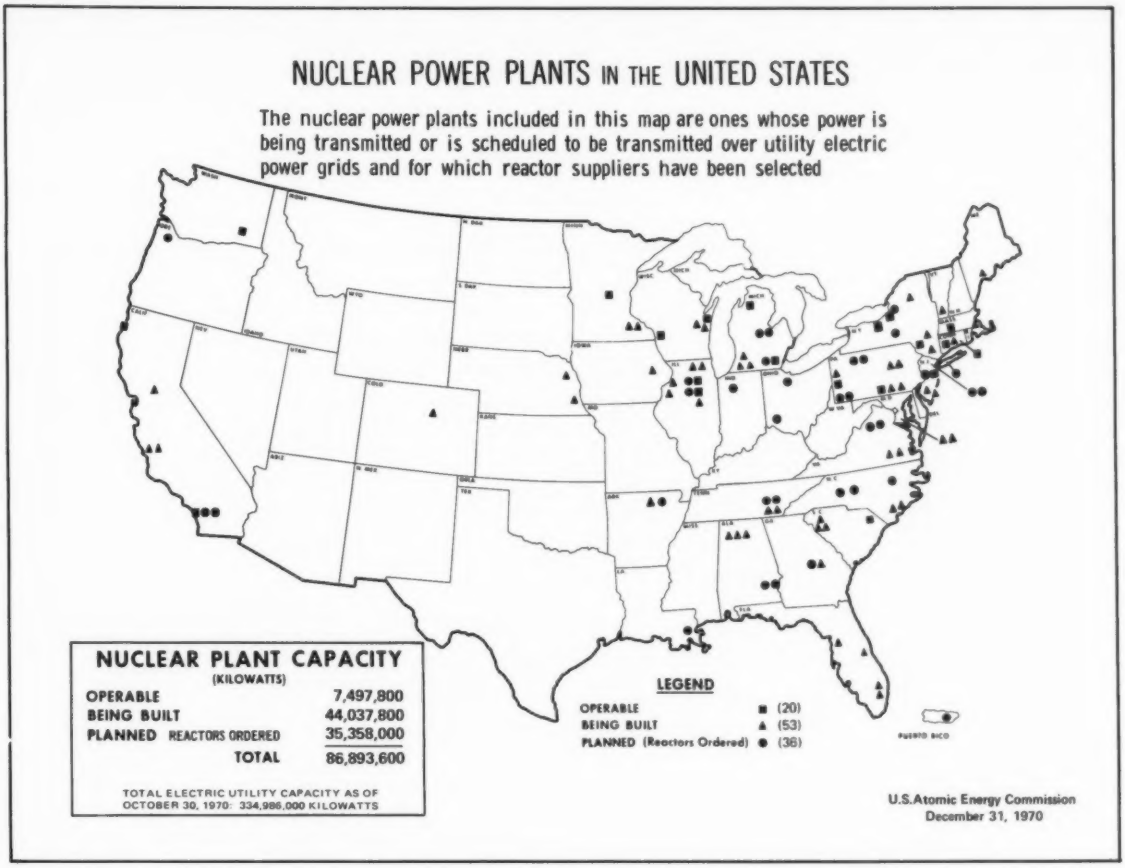

Figure 1. Nuclear power plants in the United States—continued

Reported Nuclear Detonations, February 1971

(Includes seismic signals presumably from foreign nuclear detonations)

There were no nuclear detonations or seismic signals reported by the U.S. Atomic Energy Commission for February 1971.

Information in this section is based on data received during the month, and is subject to change as additional information may become available. Persons requiring information for purposes of compiling announced nuclear detonation statistics are advised to contact the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

ERRATA

In the article entitled "Radioactive Cesium in Estuaries" that appeared in the December 1970 issue of *Radiological Health Data and Reports*, an error occurred in the first paragraph of the second column on page 661. The first sentence should read:

"The Patuxent River (table 4) has a cesium-137 distribution similar to that of the bay; that is, the ratio of cesium-137 to salinity is about *0.02* in the surface water and about *0.01* near the bottom."

On page 665, reference 5, should be corrected to read:

(5) GROSS, M. G. New York City—A major source of marine sediment, . . .

Authors note: The cesium-137 data obtained from references 6 and 7 were estimated from strontium-90 data using a cesium to strontium ratio of 1.5.

On page 693 of the December 1970 issue, a topographical error occurred in table 1 of the article, "Tritium in Community Water Supplies, 1969." The tritium concentration in the sample for Pueblo, Colo., collected from 6/13 to 6/26 should be changed from 2.0 ± 0.2 to 1.0 ± 0.4 nCi/liter.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the conveneince of readers who may wish to clip them for their files.

SUMMARY OF ENVIRONMENTAL MONITORING AT AMES LABORATORY, 1962–1969. *J. J. Copp. Radiological Health Data and Reports, Vol. 12, February 1971*, pp. 119–128.

The Ames Laboratory Research Reactor facility (ALRR), operated for the U.S. Atomic Energy Commission by the Iowa State University of Science and Technology, reached full power in July 1965. The preoperational and present environmental monitoring program consists of gross alpha and gross beta radioactivity determinations of air, soil, vegetation, river water, ALRR outfall, river bottom sediment, precipitation, well water, and pond water samples.

The average beta radioactivity levels in air ranged from 3.86 pCi/m³ in 1963 to 0.12 pCi/m³ in 1967. The 1964 average level of beta radioactivity (1.26 pCi/m³) was about one-third of the 1962–1963 average levels.

The beta radioactivity in soil increased from 1962 to a peak of 20 pCi/g in 1964, probably due to weapons fallout, then decreased to a plateau of 13–15 pCi/g in 1965 through 1969. The alpha radioactivity increased from 1962 to 1964 and leveled to a plateau (1964–1969) of 0.7–1.0 pCi/g.

Vegetation samples showed decreasing levels of beta radioactivity to 20–30 pCi/g. The alpha radioactivity in vegetation was variable with a general decrease from 1962 to 1965, leveling to 0.1–0.2 pCi/g in 1966–1968 and showing a rise to 0.91 pCi/g in 1969.

Beta radioactivity concentrations in suspended solids of collected water samples ranged from the maximum of 248 pCi/liter in 1963 to a minimum of 4.70 pCi/liter in 1967.

The environmental data indicate that any radiation that may have been contributed to the environment by the Ames Laboratory Research Reactor facility could not be detected.

KEYWORDS: Air, Iowa, precipitation, radionuclides, reactor, soil, surveillance, vegetation, water.

RESULTS OF RADIATION SAFETY SURVEYS OF X-RAY FACILITIES WITHIN THE BUREAU OF PRISONS AND FEDERAL HEALTH PROGRAMS SERVICE. *Lois A. Miller* and *LaVert C. Seabron. Radiological Health Data and Reports, Vol. 12, March 1970*, pp. 129–135.

This report presents the results of comprehensive surveys of x-ray facilities in 26 Bureau of Prison installations and in 11 hospitals and 20 outpatient clinics of the Public Health Service throughout the United States. Facility workloads, types of equipment, operator training, and equipment deficiencies are discussed.

KEYWORDS: Collimation, dental x-ray facilities, diagnostic x-ray equipment, filtration, fluoroscopic machines, radiographic machines, radiation surveys, United States, x-ray.

COLOR TELEVISION SURVEY IN PENNSYLVANIA. *Richard A. Lane. Radiological Health Data and Reports, Vol. 12, March 1971*, pp. 137–138.

During 1968–1970, 322 color television sets in Pennsylvania were surveyed for emissions of x radiation. Eighty-seven percent were found to emit radiation less than or equal to 0.1 mR/h. Two percent emitted radiation in excess of 0.5 mR/h. It was determined from the survey that the primary cause for leakage from color television sets is related to high voltage adjustments. It was found that two of the sets emitting radiation in excess of 0.5 mR/h were serviced shortly before the investigation. Voltage readings as high as 39 kV were observed.

KEYWORDS: Color television, Pennsylvania, survey, x-ray

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